HYGIENE OF COMMUNICABLE DISEASES

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A Handbook For Sanitarians, Medical Officers Of The Army And Navy And General Practitioners

By

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DEDICATED

TO

THE MEMORY OF MY FATHER,

REV. FRANCIS M. MUNSON, M.A., LL.D.

CHAPLAIN, FIRST DELAWARE VOLUNTEER INFANTRY,

WAR WITH SPAIN

PREFACE

The aim of this manual is to present in a concise and readily accessible form the information now available concerning epidemiology and the management of the communicable diseases, ashore and afloat. With this end in view their various phases have been carefully separated so that the reader may quickly obtain the information sought on any particular point under all conditions of civil, military, and naval life. The writer's experience as a medical officer and sanitarian in different parts of the world leads him to believe that such a presentation of the subjects of epidemiology, prophylaxis, and sanitation will save the time of the physician, sanitarian, sanitary engineer, missionary, or medical officer, and be of real, practical value to him when he is confronted with the danger or is in the actual presence of any of the communicable diseases, whether in sporadic, endemic, or epidemic form. The sanitary measures and procedures indicated in various emergencies and under varying conditions are described in carefully headed sections, sub-sections and paragraphs in a manner that, it is hoped, will enhance the value of the book as a work of ready reference. New features are considered; sanitary measures following great disasters, for example, have not heretofore been discussed in a textbook. In Part II each disease is considered separately, and directions are given for its control. The general plan of this part of the work is that followed by the Committee on Standard Regulations of the American Public Health Association in their report entitled, "The Control of Communicable Diseases," published as Reprint No. 436 from the Public Health Reports.

In the preparation of the book only the most trustworthy authors have been consulted, and no statement is made that is not supported by competent authority. In addition to the standard works and articles in periodicals in English on hygiene, sanitation, bacteriology, and pathology, the leading French, Italian, and, to a limited extent, German medical magazines have been consulted and quoted. Much information given to the author by prominent civil, military, and naval sanitarians by letter and by word of mouth has been utilized.

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FRANCIS M. MUNSON.

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PART I—EPIDEMIOLOGY, PROPHYLAXIS AND SANITATION

CHAPTER I

THE CAUSES OF COMMUNICABLE DISEASES

All diseases may be classified as either constitutional or environmental. Constitutional diseases are those due to inherent, acquired, or hereditary defects developed in the course of the wear and tear, nutrition, and waste of the body. Their prevention comes particularly within the province of personal hygiene, and only such phases of the latter as concern the keeping of the body in condition to resist the action of parasitic forms of animal and vegetable life will be discussed in this work. Environmental diseases are caused by agents such as sunlight, heat, physical force, and corrosive poisons acting upon the body from without, and by the invasion of the body by animal and vegetable organisms. Their prevention is a function of public hygiene and sanitation, but becomes possible only through the willing or compulsory cooperation of the individuals or communities exposed or affected.

By far the most important division of environmental diseases is that class caused by the entrance into—and in most cases the multiplication in—the body of low forms of animal and vegetable life. These diseases have been called "infectious," "contagious," "zymotic," "zymotoxic," "specific," "germ," and some of them "miasmatic." These terms are misleading and confusing. It is better to include them all under the term "communicable." Communicable diseases are those caused by the lower forms of plant life, bacteria, molds, and yeasts, and by protozoan and metazoan animal parasites which are communicated directly or indirectly between man and man, between animal and man, and between animal and animal. These organisms, being dependent on the tissues for food, are parasites; therefore the affections caused by them are parasitic conditions.

For purposes of study the etiology of the communicable diseases is divided as follows: 1. Predisposing Conditions; (*a*) Remote, (*b*) Immediate. 2. Exciting or Biological Causes; (*a*) Animal, (*b*) Vegetable.

Predisposing Conditions

Remote.—*Age.* Mortality is greatest in the years of growth and decline, dropping lowest during adolescence and the early years of maturity, and reaching its highest point in children under one year. It decreases rapidly from the second until the fifteenth year, and then gradually increases until the sixth decade, when it again decreases.

Some diseases, such as tuberculosis, are common to all ages, but manifest themselves differently according to the age of the subject. In childhood tuberculosis is more likely to appear in the lymphatic or osseous systems or the serous tissues; during maturity and old age the lungs are more apt to be affected.

In infancy and childhood a large percentage of morbidity is connected with the development of anatomical structures and the establishment of physiological functions. The influence of hereditary tendencies and disease, congenital defects, ignorant and careless mothers, hard work during and after pregnancy, improper food and clothing, and lack of fresh air and cleanliness are seen at this period. High infant mortality is due to faulty nutrition caused by artificial feeding, and secondarily to catarrhal inflammations, of microbic origin, of the gastro-intestinal and respiratory tracts. Some of the acute exanthemata—measles, rötheln, varicella, and scarlatina,—occur most frequently in childhood and early youth. The more or less permanent immunity thus bestowed accounts for their comparative infrequency in adult life; while their morbidity and mortality are high in childhood, they are relatively low during the first year, the opportunities for direct contact infection being somewhat less during that period.

Erysipelas, variola, and typhus may occur at any time of life.

In adult life the diseases depend very largely upon conditions under which the subject lives. Typhoid fever occurs most frequently during youth and early adult life, from the fifteenth to the forty-fifth year. This lacks satisfactory explanation.

It is hard to specify the beginning of old age or decline; "a man is just as old as his arteries." The vague terms "old age" and "general debility" simply denote degenerations of the tissues and organs, especially the vascular system. During this indefinite period the effects of the wearing out of the machinery of the body are seen. The circulatory, renal, and hepatic systems are principally affected, and catarrhal conditions of the mucous membranes and terminal pneumonias are frequent. It is during this era that the seeds sown in early life grow to mature harvests and are reaped. The results of intemperance in eating and drinking, of syphilis with its sequelæ, and of early hardships and exposure are manifested. Malignant disease and tumors are most frequent at this time of life.

Sex. The general death rate among females is uniformly lower than among males, who are in closer contact with conditions that influence their health. Among these may be mentioned exposure to the unhygienic conditions and accidents of industrial life, the risks to health and life involved in warfare and exposure to the elements, which lower the power of resistance to protozoal and bacterial attacks. In the diseases that depend upon anatomical structure the influence of sex as a predisposing factor is obvious. Before puberty the influence of sex is less evident. Statistics seem to show that males are more liable to venereal diseases, alcoholism, gout, locomotor ataxia, epilepsy, acute diseases of the respiratory tract, hydrocephalus, trismus nacutum, convulsions, diseases of the brain and cord, aneurysm, angina pectoris, laryngitis, lead and other poisoning, diseases of the liver, urinary calculus and other diseases of the genito-urinary tract, diseases of the bones and spleen, typhoid fever, and accidents.

Females are, of course, exposed to diseases of the female reproductive organs, pregnancy, and child-birth, with the possible infections to which the latter exposes them. Apparently the following diseases occur more frequently in females: hysteria and allied nervous diseases, cancer, anemia after puberty, ascites, diseases of the stomach, and peritonitis.

Hæmophilia is essentially a disease of men, and osteomalacia of women.

In some cases the reasons for the occurrence of certain diseases in one or the other sex are manifest, in others they are obscure or unknown.

Hereditary Influences. These are shown in the greater prevalence of certain diseases in one family than in others; they are inescapable except through the science of eugenics, and are intensified by intermarriage of near relations, as the influence on offspring may be present in both parents.

It was formerly believed that there was actual hereditary transmission of disease, such as tuberculosis, but this theory has been largely discredited since the discovery of the specific causes of many diseases. Except in a very few instances it is the predisposition or susceptibility that is transmitted, persons inheriting this quality developing the disease far more readily than those who are free from the taint. Direct transmission from parent to offspring, except syphilis from either parent and acute diseases from the mother, is controversial. Intrauterine tuberculosis exists, but is very rare, what is transmitted being an enfeebled constitution with the special predisposition. Intimacy with the diseased parents, particularly the mother, gives abundant opportunities to the enfeebled offspring for infection. It is frequently impossible to distinguish between hereditary and acquired tuberculosis.

Some families show a marked predisposition to the communicable diseases, others marked resistance.

Hereditary predisposition to the following diseases is recognized: carcinoma, rheumatism, diseases of the circulatory organs, diseases of the nervous system—especially insanity and hysteria—malformations, hemophilia, and osteomalacia.

Race. Racial immunity and susceptibility are much more pronounced in the lower animals than in man. Trustworthy data are very difficult to obtain, as many determining factors, such as social conditions under which different people live, make statistics unreliable; their value can be considered as relative only. A relative racial or class immunity may be developed by common exposure to the same diseases in a given locality. The apparent immunity of the inhabitants, especially Negroes, of endemic centers to yellow fever is an example. The comparative immunity of city-bred men and the relative susceptibility of countrymen to measles, scarlatina, and pertussis, is seen in the almost invariable outbreaks of these diseases in newly raised regiments of volunteers from rural districts and the few cases among the city regiments.

Races accustomed to a primitive life such as the North American Indian, Eskimos, Filipinos, etc., show little resistance to tuberculosis when brought under civilized conditions.

The exanthemata, especially measles, are comparatively mild in civilized races, but most severe and fatal in savage races, especially the inhabitants of the islands of the Pacific.

The Jews show great resistance to tuberculosis, cholera, plague, and other communicable diseases. In the Middle Ages, because of this, they were accused of spreading disease among the Gentiles by poisoning the wells and other means. This relative immunity of the Hebrew is not to be wondered at when we consider that he drinks less, eats better food, marries earlier, takes better care of his children, his old, his poor, and himself, than the average individual of other races, and still respects the Mosaic Laws. The Jew seems to be susceptible to diabetes, nervous diseases—especially of the spinal cord—diarrheal diseases, diphtheria, diseases of the circulatory organs and urinary system, bones, joints, and skin. The high morbidity from skin diseases is due in part to lack of personal cleanliness among the lower class of Jews, especially those from Poland and Russia.

The Negro, while apparently having some degree of immunity to yellow fever and malaria, is very susceptible to tuberculosis and cholera.

The Japanese have a relative immunity to scarlatina. The Chinese have many times shown a strong racial immunity to cholera.

Conjugal Condition. The death rate is lower among the married than among the single or widowed, the more regular lives and the better care received, especially when sick, offering some explanation of this fact. Among widowed males the mortality is high. Age is an important factor in these cases.

Hygienic Environment and Density of Population. Density of population is a valuable index of the morbidity and mortality in a community. This is true for all ages, but especially so for the very young, in centers of dense population. "The dissemination of infection is in inverse ratio to the distance between individuals congregated together in a habitation: the greater the distance the less, the less the distance the greater the liability for infection to spread."[1]

It is not the small number of units of living space per inhabitant, but the concomitant factors, that produce the high mortality of crowded communities. On a modern man-of-war the crew live in crowded quarters, but the conditions of filth and poverty being absent, the morbidity is very low. The important factors increasing the death rate in centers of dense population are: increased opportunities for direct infection, filth, insufficient and improper food, inadequate clothing, deficient shelter, and the general lack caused by poverty in general.

To the densely crowded centers gravitate the poverty-stricken and the racial failures, and from here emanate the persons with deficient resistance to communicable diseases, those of unclean habits, the improperly and insufficiently nourished, those engaged in unhealthful occupations, those ignorant and careless in guarding themselves against unfavorable influences, and also the human wrecks from the half world and the underworld.

Certain conditions of environment are frequently inseparable from dense population, e.g., deficient and impure water supply, poor drainage, and dampness of soil, all predisposing to a high rate of morbidity.

The diseases especially prevalent in areas of dense population are tuberculosis, the acute exanthemata, gastro-intestinal disorders of childhood, catarrhal affections, rheumatism, venereal diseases, and in some localities malaria and yellow fever.

Occupation. The large majority of communicable diseases in which occupation is a predisposing condition are due rather to the unhygienic conditions under which the work is per-

[1] Abbot, "Hygiene of the Transmissible Diseases."

formed than the character of the work itself. A moderate amount of work under proper conditions is conducive to health, but labor in poorly ventilated, improperly heated, damp, uncleanly and dusty factories, workshops, and offices predisposes to disease. To these conditions should be added lack of proper sanitary arrangements and facilities, disinclination for bodily cleanliness, exposure to extremes of weather, and tendency to dissipation.

The influences of occupation may be general, such as long mental exertion, emotional excitement, long hours, inhalation of vitiated or toxic air, exposure to trauma and extremes or variations of temperature and alterations in atmospheric pressure, actions of various kinds of radiant energy, and low wages with their resultant deficient nutrition. Among local predisposing conditions may be mentioned exposure in handling infected materials, as hides from animals suffering from anthrax; cramped attitudes, such as interfere with the action of the heart or lungs; the over-use of certain organs, and the inhalation of finely divided dust. A number of industrial occupations predispose to diseases of the lungs, especially tuberculosis and the different pneumonias from the latter cause. The effects differ with the physical character of the dust inhaled.

The occupational diseases, such as the neuroses, as such, are not within the scope of this work.

Climate and Season. The human body is very adaptable to climatic conditions. With proper food, clothing, and exercise, and the avoidance of the biological causes of disease, climate becomes a minor factor as a cause of morbidity. With the exception of heat stroke, neurasthenia, frost bite, and possibly anemia, climate acts only as a predisposing condition in the causation of disease. The better understanding of the parasitic nature of communicable diseases has decreased the importance of climate in etiology and epidemiology. However, these discoveries in bacteriology and parasitology have not lessened the importance of climate and seasons as prophylactic measures and therapeutic agents.

Climates are classified as follows: Warm—Equatorial, tropic, subtropic; temperate,—mean temperature 60° F.; cold. They are also classified as Plain, Mountain, and Marine. Climates are modified by latitude, altitude, proximity to bodies of water, prevalent winds and rains, topography of land, and character of soil.

The influence of vegetation, especially trees, themselves dependent upon climates as to scarcity, abundance, and variety, is seen in the following ways: They modify the winds, equalize the temperature, make the air more uniformly humid, and lessen dust; the balsamic vapors from the pine and fir exert a therapeutic effect; wet soil is made dry by the eucalyptus; there is less danger from floods in wooded districts, as the trees regulate the flow of water from the soil.

Warm, moist climates favor the growth of animal and vegetable parasites. This is especially seen in the tropics, where gastro-intestinal disorders are common and favorable conditions exist for the growth of the causative agents of cholera, yellow fever, malaria, the metozoal intestinal parasites, and for the insects that disseminate communicable diseases.

Cold climates, because of the conditions under which people live, i. e., in closely confined, ill-ventilated houses, favor the spread of the acute exanthemata and tuberculosis, and the development of rheumatism, gout, pneumonia, and other pulmonary diseases.

Measles and scarlatina are rare in hot countries.

Marine climates predispose to rheumatism and pulmonary affections and aggravate existing neuralgias.

The diseases prevalent during the seasons of low temperature and excessive moisture in temperate climates are those most common in cold countries. These are catarrhal affections, especially of the respiratory tract, pneumonia, rheumatism, gout, diphtheria, and the acute exanthemata, especially measles, scarlatina, and variola. The chilling of the body, resulting in decreased powers of resistance, the less hygienic mode of living, as more time is spent in ill-ventilated and overheated rooms for warmth, and the tendency to overeat and drink are the predisposing factors. The communicable diseases are especially likely to prevail through the greater facilities for direct and indirect contact infection offered by poorly ventilated and uncleanly houses, schools, and public meeting places. The low temperature, *per se*, is not a strong predisposing condition in the morbidity of communicable diseases in cold climates and seasons.

During the hot months in cool climates the diseases characteristic of lower latitudes prevail. It is at this time that tropical diseases such as cholera, yellow fever, and dengue make their incursions into the temperate zones. Yellow fever and dengue are dependent on the life of the respective mosquitoes that transmit the diseases. They cannot survive the cold weather.

Diseases of the digestive system, especially in young children and others whose food consists of materials that readily undergo fermentation in hot weather, prevail in hot seasons and countries. Cholera infantum reaches its height during July and August, the period when it is most difficult to preserve the food of infants. Cholera Asiatica appears during August, September, and October, its prevalence and that of typhoid fever being possibly influenced to some extent by the greater number of flies during these months. Cholera and typhoid fever are not so common in winter, when there are few flies, and when the possibilities for their propagation and transmission through the public water supply are lessened.

Malarial diseases are most prevalent during the periods of greatest development of the specific mosquito.

Tuberculosis is more abundant in moist climates at the sea level, and is less frequent in dry, higher regions.

The acute exanthemata reach their highest frequency from late autumn to early spring, the period when children are in school, with increased opportunities for contact infection.

Excessive dryness or moisture in any season may increase the morbidity.

Immediate Predisposing Conditions. The physical and chemical agents embraced in this subheading act by lessening or destroying the local or general power of resistance normally possessed by the body.

Exposure to Extremes of Heat and Cold. The human body compensates for increase of temperature up to 130° F. by augmented evaporation of water. Higher temperatures than this will endanger life, though temperatures up to 400° F. in the form of dry heat may be applied for short periods of time without injury. The dilatation of the blood vessels by extreme heat favors certain forms of infection, such as coryza. Pronounced exposure to moderately high temperature, solar or artificial, especially if associated with excessive use of alcohol, predisposes to insolation, heat, and neurasthenia. In industrial life heat exhaustion is frequently seen among stokers, steel-workers, and bakers, all of whom are exposed to high degrees of artificial heat.

Local or general cooling of the body increases susceptibility to certain infections: pneumonia, pleurisy, nephritis, and enteritis frequently follow the chilling of the body surface. Acute congestion of the lungs and acute nephritis are not infrequently the result of a sudden change from extreme heat to extreme cold.

Those exposed to all kinds of weather are predisposed to pneumonia. Those exposed to extremely cold weather are in danger of chilblain, sometimes resulting in gangrene.

Dampness or Undue Dryness of the Atmosphere. Both of these conditions may induce respiratory troubles such as bronchitis. Dampness especially may lead to pneumonia. Continued exposure to dampness predisposes to rheumatism and excessive dryness to conjunctivitis.

Exposure to Strong Currents of Air. Those working in strong draughts are subjected to rheumatism, neuralgia, and pleurisy, especially if the air is cool or cold.

Undue Exposure to Bright Light. Sunlight, light from the electric arc, calcium light, acetylene gas, and especially the Welsbach light, all cause retinitis in the unprotected eye. Strong lights affect the pigment in the dermal cells, leading to tanning and freckling. The sun and the electric light, if the exposure is long and the subject is in close proximity, may lead to acute dermatitis with vesication followed by suppuration. The light rays of the tropical sun are a strong factor in the etiology of tropical neurasthenia, so common among white people in the tropics. The solar light rays influence the general nutrition, increasing tissue oxidation and the elimination of carbon dioxide. While the influence of the solar rays extends millions of miles, the electric light extends only a few meters, the cathode rays a few centimeters, and Becquerel's rays only a few millimeters.

Prolonged absence of sunlight is a cause of anemia and renders the victim susceptible to tuberculosis, as shown by the prevalence of these diseases among convicts.

Sound. Auditory impressions on the higher cerebral centers may cause exaltation or depression. Nervous excitement, joy, or moroseness may result from certain discordant or musical sounds, while the street noises of large cities are a cause of neurasthenia, hysteria, and chorea. Silence or the lack of noise in rural districts favors introspection, and this leads to melancholy; continued exposure to racking, irritating noises tends to insomnia; continued monotonous sounds have a soporific effect; sudden, loud noises, as gun-fire, cause distress and sometimes deafness; constant noises, as in machine or boiler shops, predispose to and may cause deafness.

Deficient Diet. The total deprivation of food will obviously result in death by starvation. Lack of sufficient food leads to weakness, marasmus in children, and cachexia in adults, conditions in which they readily fall victims to the communicable diseases.

A diet deficient in potassium salts (or citrates, malates, and lactates) causes scurvy, which, if not the direct cause of the death of the subject, renders him highly susceptible to any intercurrent communicable disease to which he may be exposed.

Excessive Diet. An excess of food is a cause of gastro-intestinal catarrh, which renders the body susceptible to such communicable diseases as typhoid fever, dysentery, and cholera. Excessive nutrition also causes obesity, chronic nephritis, and hepatitis, in all of which conditions there is a lowered state of resistance to infection by the communicable diseases.

Alcoholism. Clinical observation and laboratory experiments show that alcohol increases susceptibility to infection. The results in laboratory animals are the same whether given at the time of inoculation or by mouth or skin. As the result of experimentation it is observed that abnormal temperatures in animals to which alcohol has been given last longer than in control animals to which alcohol has not been given.

Pneumonia, tuberculosis, cholera, typhoid fever, yellow fever, and septic infections are more severe and frequent in alcoholics than in the temperate. The tissues, as the result of the continued use of alcohol, get into a depraved condition, and the power of assimilation of food is decreased, thus lowering the capacity of resistance to invasion by pathogenic organisms.

The immediate use of alcohol is a stepping stone to indulgence in other forms of dissipation, such as gambling and sexual vice, the latter paving the way to venereal infection. Alcohol induces sexual desire, obtunds the moral sense, and leads to disregard of the dangers of infection.

The damage done the body depends somewhat on the character of the alcoholic drinks imbibed. Malt liquors are a cause of parenchymatous and fatty degeneration of the viscera; distilled liquors cause gastro-intestinal disorders and scleroses, especially of the liver, kidneys, and central nervous system. Ardent spirits also cause neuritis, palsies, obscure neuroses, and psychoses, as well as clearly defined types of the two latter.

Drug Habits. The habitual use of narcotic drugs, particularly cocaine, opium, and its derivatives—morphine, heroin, and laudanum,—chloral and cannabis indica, rapidly reduces the power of resistance of the human system, leaving a fertile field for attack by the communicable diseases.

Undue Physical Exertion. Overwork by the toiler and over-exertion by the sportsman result in overcoming their ability to withstand the attack of disease, while after an exhausting campaign the morbidity among soldiers from communicable diseases is always increased.

Undue Mental Exertion. Inordinate ambition, seen so frequently in this era of speed mania in all affairs of life, is reaping a rich harvest of broken constitutions in middle life, many of the victims having primarily developed such neuroses or psychoses as neurasthenia or paresis, and being finally carried off by pneumonia or tuberculosis. Depraved and perverted emotions and depressing and exhausting habits all lead to the same result through the undue dissipation of energy.

Sexual Excesses. Excessive venery predisposes to diseases of the nervous and circulatory systems, and indirectly to venereal and other communicable diseases and their sequelæ.

Loss of Sleep. Lowered powers of resistance and ultimately neurasthenia and insanity are frequent results of lack of sleep.

Maintenance of Body in Abnormal Positions for Long Periods of Time. Stooping and other incorrect positions are a predisposing factor in tuberculosis.

Constriction of Body by Wearing Apparel. Too tight clothing obviously acts only in a general way, by lowering local and general resistance.

Mechanical Injury. Open wounds offer fields for infection, especially by the pyogenic organisms. Punctured wounds are liable to infection with *Bacillus tetanus, Bacillus aerogenes capsulatus,* and the bacillus of malignant edema. The growth of certain pathogenic bacteria is favored by devitalization of the tissues. Saprophytic bacteria grow well in injured tissues, and result in sapremia.

Trauma, or the abrupt application of mechanical violence, often determines the localization of infectious organisms in the circulation, especially the bacillus of tuberculosis.

Association with Animals. The infection of the dairy maid's hands with cowpox from the diseased udders of the cow, and its study by Jenner need not be recalled to students of medicine. The discovery of the rat as the reservoir of plague is of vital importance. Hostlers and others associated with horses are at times infected with glanders; drovers and others in contact with cattle are in danger from anthrax, if any of the animals are infected; butchers and veterinary surgeons are sometimes inoculated with tuberculosis from diseased animal tissues. Psittacosis, a communicable pulmonary disease of parrots, has been fatally transmitted to man. Rabies is generally caused by the bite of the dog, though occasionally it is communicated through the victim being bitten by wolves, wildcats, skunks, and other animals.

The results of contact with the parasitic and suctorial insects are fully dealt with in the section on "Dissemination of the Communicable Diseases."

The big game animals of Central Africa act as reservoirs for the trypanosome causing "sleeping sickness" in man.

Infestation of man with the metazoal parasites, especially the worms, by reason of their developmental cycle, occurs frequently where man and the lower animals live in close association. A marked example of this is the intimate association of the Icelanders with their dogs and the constant high percentage of sufferers from *Tœnia echinococcus* among that race.

The Exciting or Biological Causes of Communicable Diseases

Exciting causes are the animal and vegetable organisms that are capable of existing in or upon the bodies of other living organisms. They give rise to disorders of function and structure either by their mere presence causing local irritation or obstruction, by absorbing nourishment from the body, or by the generation of toxic secretions or excretions which in turn produce disease through their local or general action. They are commonly spoken of as animal and vegetable parasites, or zoo parasites and phytoparasites respectively.

The study of the animal parasites is called parasitology, and that of the vegetable parasites is known as bacteriology.

Animal Parasites.—*General Considerations.* The number of animal parasites has been very much underestimated, it being now known that all classes of animals, except possibly the Echinodermata and Tunicata, harbor living parasites. Some large zoölogical classes, as Sporozoa, Cestodes, Trematodes, and Acanthocephala, contain only parasitic species. The morphology of an animal is no criterion of its mode of life, as examples of parasitism are known among the vertebrates (Myxine).

Certain species of animals, as the Culicidæ (mosquitoes), and Pulicidæ (fleas), cause disease by introducing into their hosts pathogenic microörganisms, animal and vegetable. Others, as the goat, act more indirectly by harboring the germs of Malta fever in their body fluids. The plague-infected flea is brought into man's vicinity by the rat.

Ways and Degrees of Parasitism. The host is the animal that harbors the parasite. Many parasites require two hosts for their life cycle—an intermediary host, in which the larva develops, and a definite or final host, in which the sexual life is passed. The malaria parasite passes the larval stage of its existence in man, who is therefore the intermediary host, and its sexual life in the mosquito, its final or definite host. Some parasites, for example the hookworm, complete their life cycle in one host.

Hyperparasitism is the occurrence of animals living a parasitic life upon or in another parasite. Four distinct species of parasites have been known to be involved in a single case of this phenomenon.

Temporary or *occasional* parasites resort to their hosts only at times for purposes of food and incidental protection. Such are the flea (*Pulex irritans*), bedbug (*Cimex lectularia*) and leech (*Hirudo medicinalis*). They are not bound to the host in any way, and usually depart after securing their nourishment (Cimex), though some, as Pulex, pass their entire adult life on the body of their host. These are called *stationary* parasites. *Periodical* parasites spend only a given period of their life upon their host; such are *Strongyloides stercoralis,* in the human intestine.

Permanent parasites are those whose entire life cycle is parasitic.

True parasites are those that do harm to the host, deriving all the benefit from the association. The hookworm infesting man is an example of this species.

Pseudoparasitism is the accidental entry into and sojourn of living organisms in the body of other living organisms, playing no part in the life history of the latter. Such, for instance, is the passage of the larvæ of flies through the alimentary tract of man. Objects mistaken for parasites are sometimes spoken of as pseudoparasites.

Mutualism is a condition in which both host and parasite derive benefit from the association. The oyster crab, residing inside the oyster shell, is an example.

Commensualism is an association from which the parasite derives benefit and no harm is done the host. The presence of *Trichomonas vaginalis* in the vaginal mucus exemplifies this.

As a rule parasites keep strictly to certain hosts called "normal hosts," but at times they are found in unusual hosts.

Such a parasite is called a *chance* parasite. An example of this is *Echinorhynchus gigas,* usually found in pigs, but which may infect man.

Ectoparasites or *epizoa* inhabit the skin and exterior of the host. *Endoparasites* or *entozoa* infest the internal organs or cavities of the host.

Animals that cause and convey the diseases of man and other animals are classified into the following subkingdoms: Subkingdom I, *Protozoa.* Subkingdom II, *Metazoa.*

Subkingdom I, **Protozoa**

Definition. Protozoa are morphologically and functionally complete animal cells, living a solitary or colonial life, free living or parasitic. A protozoan is not one of a number of cells making up a complex individual and mutually dependent on each other as in the metazoa. Colonies of protozoa are composed of masses of independent organisms, there being no differentiation into tissues in protozoa.

Classification of Protozoa

Phylum: *Protozoa*
  Class: *Rhizopoda* (Sarcodina)
    Order: *Gymnaœba*
      Genus: *Entamœba*
        Species: *E. coli*
          E. histolytica
          E. tetragena
          E. gingivalis
      Genus: *Lydenia*
        Species: *L. gemmipara*

Bodies soft, but may have external protecting shell; shape continually changing, due to protoplasmic extensions or pseudopodia of various shapes and sizes used for locomotion and to secure food.

Class: *Flagellata* (*Mastigophora*)
Order: *Gymnaœba*
Genus: *Spirochæta*
Species: *S. recurrentis*
S. vincenti
S. duttoni
S. carteri
S. refringens
Genus: *Schizotrypanum*
Species: *S. cruzi*
Genus: *Treponema*
Species: *T. pallidum*
T. pertenue
Genus: *Trypanosoma*
Species: *T. gambiense*
T. rhodesiense
Genus: *Trichomonas*
Species: *T. vaginalis*
T. intestinalis
Genus: *Tetramitus*
Species: *T. mesnili*
Genus: *Lamblia*
Species: *L. intestinalis*
Genus: *Babesia*
Species: *B. bigemina*
Genus: *Leishmania*
Species: *L. donovani*
L. tropica
L. infantum

The Flagellata are armed with undulating membranes or flagella for locomotion. The body is well defined and frequently has external limiting membrane.

The Infusoria are the most highly developed of the Protozoa characterized by numerous fine cilia which are shorter than flagella, have a sweeping stroke, and are especially developed around the cystome. May be free or attached. Have contractile vacuoles, also micro- and macro-nuclei with vegetative and reproductive functions respectively.

Class: *Infusoria* (Ciliata)
  Order: *Heterotricha*
    Genus: *Balantidium*
      Species: *B. coli*

Sporozoa have no motile organs; live parasitically in the cells or tissues of other animals, especially vertebrates, reproducing by alternating endogenous or asexual sporulation and exogenous or sexual sporulation in vertebrate and insect hosts respectively. The spores are naked.

Class: *Sporozoa*
  Order: *Coccidiaria*
    Genus: *Eimeria*
      Species: *E. stiedæ*
    Genus: *Isospora*
      Species: *I. bigemina*
  Order: *Hæmosporidia*
    Genus: *Plasmodium*
      Species: *P. vivax*
        P. malariæ
        P. falciparum

The border-line between unicellular animals and unicellular plants being so indistinct, it is at present uncertain how to class some forms, whether they should be grouped with the Protozoa and considered to be animals, or with the bacteria and considered to be plants. Haeckel's proposal of a third kingdom, Protista, to include the protozoans and protophytes, would increase the practical difficulties of classification.

A general description of the phylum Protozoa is difficult, as the classes composing the group present a varied morphol-

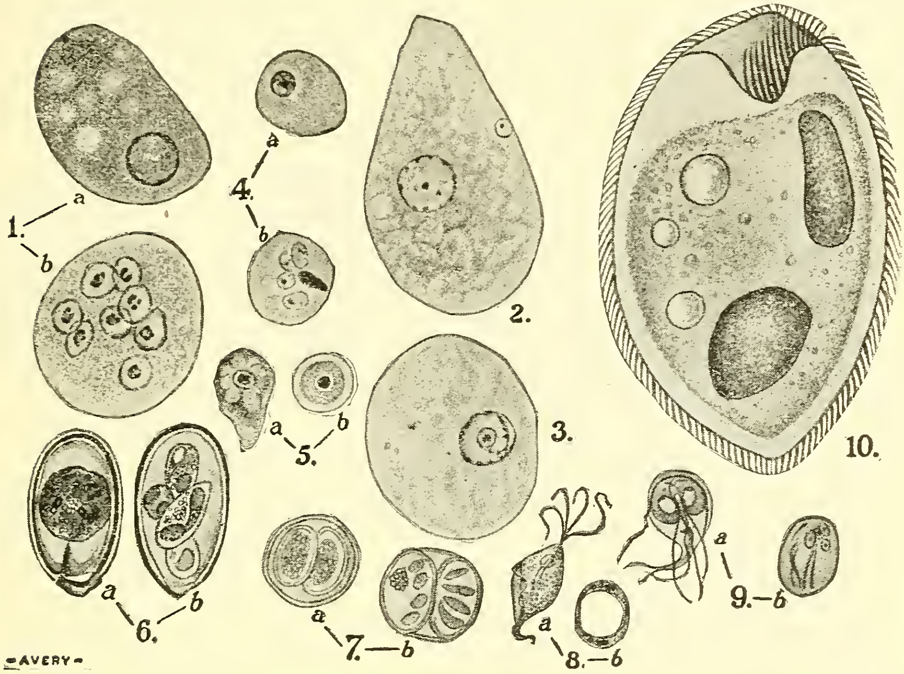


FIG. 1.—PATHOGENIC PROTOZOA OF THE INTESTINAL TRACT.

(1a) Motile *Entamœba coli.* (1b) Encysted *Entamœba coli.* (2) Motile *Entamœba histolytica* from acute dysenteric stool. (3) Tetragena type of *Entamœba histolytica* from case of chronic dysentery. (4a) Preëncysted *Entamœba histolytica* from carrier. Compare with the larger *Entamœba coli.* (4b) Encysted *Entamœba histolytica* from dysentery convalescent. (5a and 5b) Motile and encysted cultural amœbæ from Manila water supply. (6a and 6b) Oöcyst and sporozoite production in 4 spores of *Eimeria stiedæ.* (7a and 7b) Oöcyst with 2 sporoblasts and oöcyst with 2 spores containing 4 sporozoites of *Isopora bigemina.* (8a and 8b) Vegetative and encysted *Trichomonas intestinalis.* (9a and 9b) Vegetative and encysted *Lamblia intestinalis.* (10) *Balantidium coli.* (Illustrations of amœb æ from Walker—others from Doflein.) (*Stitt, Practical Bacteriology, Blood Work and Animal Parasitology, 5th Edition. P. Blakiston's Son & Co.*)

ogy. The cells are composed of protoplasm, which is frequently divided into cytoplasm and nucleus. The former is generally separated into an external portion, the ectoplasm or ectosarc, hyaline in appearance, and an internal, granular, or frothy portion, the endoplasm or endosarc. It is assumed that the protoplasm is honeycombed with minute chambers containing the enzymes and other active substances necessary for the performance of its vital functions. There are also larger and more irregularly shaped spaces called vacuoles, some temporary, containing accumulations of unassimilated food. Other

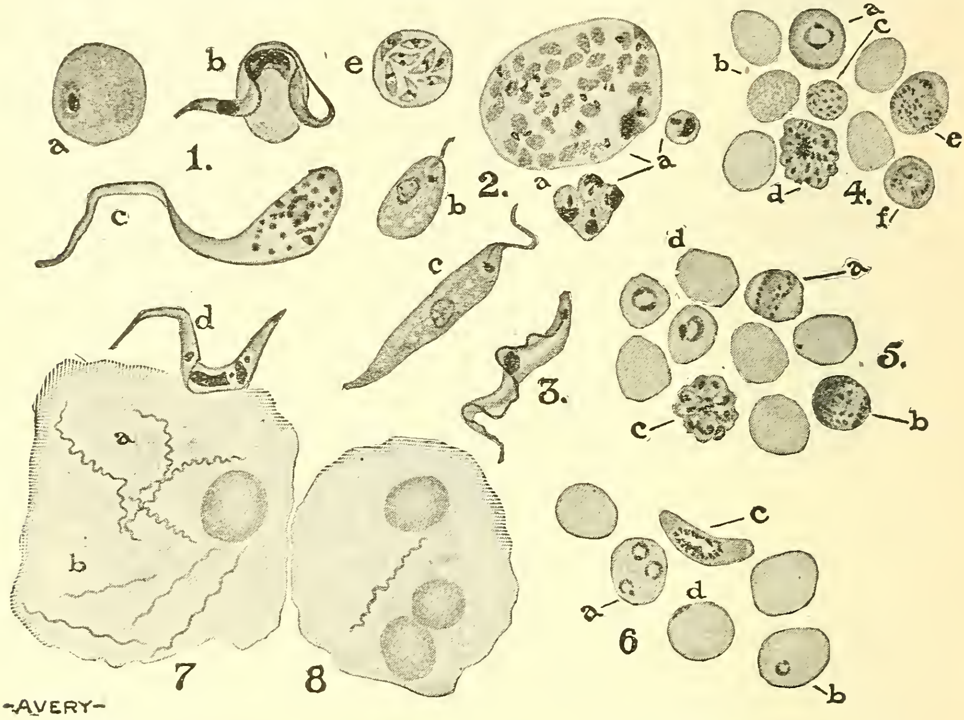


FIG. 2.—BINUCLEATA (HÆMOFLAGELLATA AND HÆMOSPOROZOA).

1. *Schizotrypanum cruzi;* (a) Merozoite just entering red blood cell; (b) fully developed trypanosome form in blood; (c) form found in intestine *Conorhinus;* (d) form in salivary gland of *Conorhinus;* (e) merocyte from the schizogenous cycle in lungs. 2. *Leishmania donovani;* parasites from spleen smear, free and packed in phagocytic cell; (b and c) flagellate forms from cultures. 3. *Trypanosoma gambiense.* 4. *Plasmodium vivax;* (a) young schizont; (b) uninfected red cell; (c) red cell, punctate basophilia; (d) merocyte; (e) macrogamete; (f) adult schizont. 5. *Plasmodium malariæ;* (a) half-grown schizont showing equatorial band; (b) macrogamete; (c) merocyte; (d) young schizonts. 6. *Plasmodium falciparum;* (a) red cell showing multiple infection; (b) young ring form; (c) crescent; (d) young schizont on periphery of red blood cell. 7. (a) *Treponema pallidum;* (b) *Spirochæta refringens.* 8. *Treponema pertenue.* (*Stitt, Practical Bacteriology, Blood Work and Animal Parasitology, 5th Edition. P. Blakiston's Son & Co.*)

spaces, larger and permanent, are presumed to be concerned in the maintenance of the cytoplasmic currents, thus aiding cell nourishment. Particles of undigested food and occasionally grains of chlorophyl are also found in the cytoplasm.

Flagella and cilia often project from the ectosarc. In some orders the differentiation between endosarc and ectosarc is not marked; in others the latter is rigid and may contain grains of mineral substance.

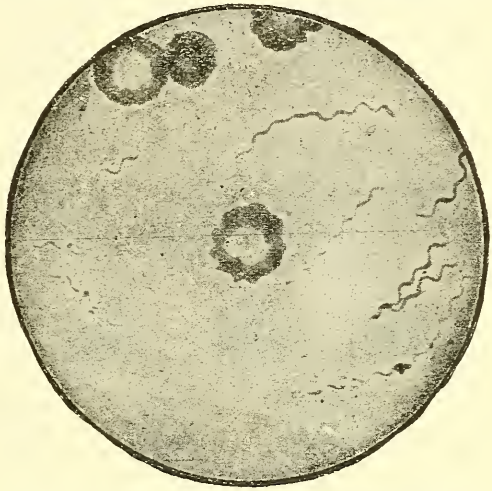
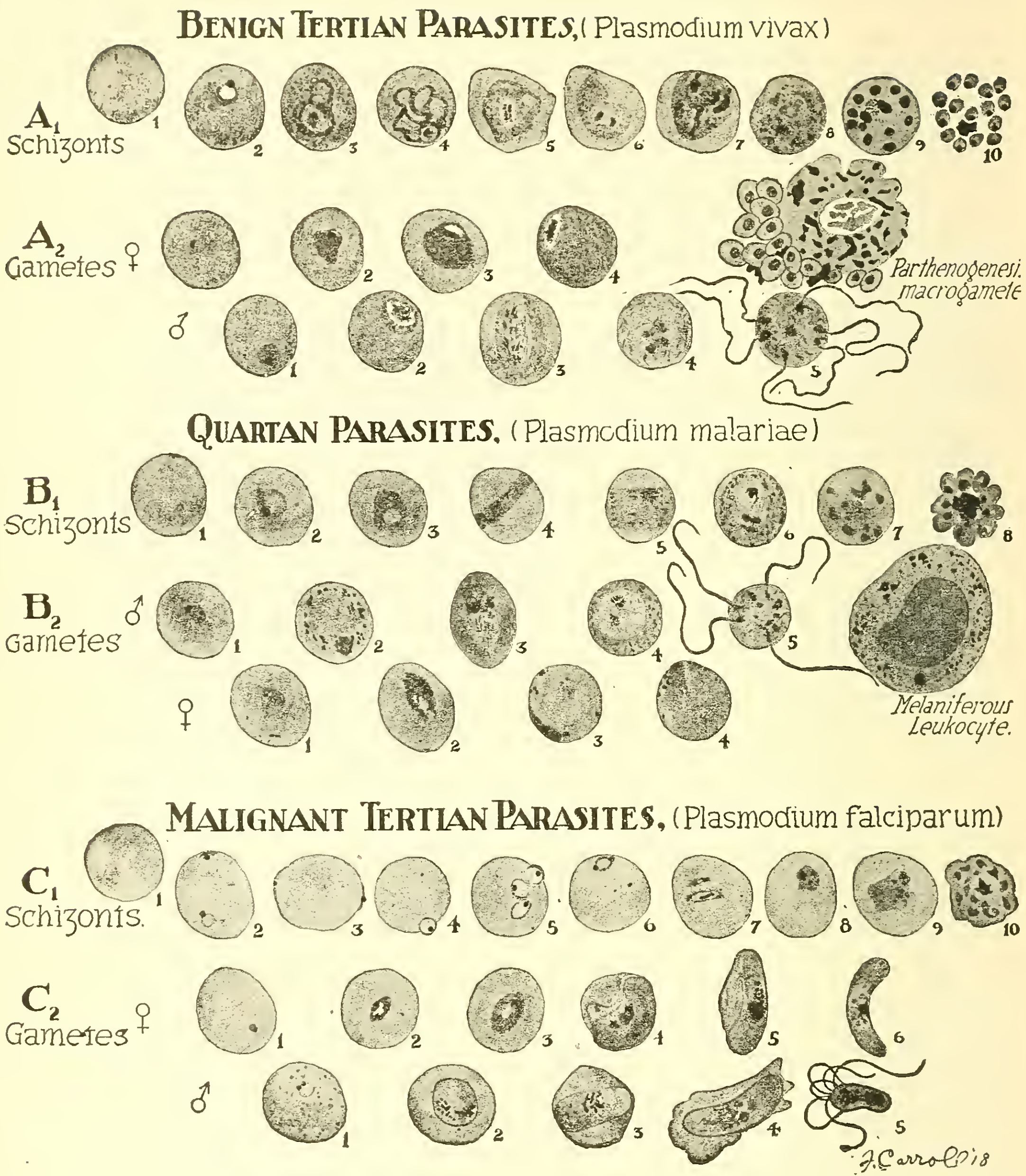


Fig. 3.—Spirochætæ of Relapsing Fever from Blood of a Man. (Kolle and Wassermann.) (*Stitt, Practical Bacteriology, Blood Work and Animal Parasitology, 5th Edition. P. Blakiston's Son & Co.*)

The trophic and reproductive functions are performed in the endosarc, while those of locomotion, protection, sensation, and excretion are localized in the ectosarc. The body substance may show no morphologic differentiation, but in some, as the corticata, there may not only be a permanent form, but also adaptations, as oral and anal apertures, communicating with the endosarc. Some of the higher Infusoria (Vorticella) possess contractile stalks with which the protozoa attach themselves.

Some of the more simple organisms, as the Spirochætidæ, have very indistinct nuclei. In the Rhizopoda the nucleus is surrounded by a distinct nuclear membrane. Many of the Mastigophora, as the Trypanosoma, have either a nucleus and a centrosome or a major and a minor nucleus. The nuclei of Protozoa are extremely diversified and vary from simple collections of nuclear matter to large, well-formed organs of curious shapes.



BENIGN TERTIAN PARASITES, (Plasmodium vivax)
A1 Schizonts
A2 Gametes ♀
♂
Parthenogenesis macrogamete
QUARTAN PARASITES. (Plasmodium malariae)
B1 Schizonts
B2 Gametes ♂
♀
Melaniferous Leukocyte.
MALIGNANT TERTIAN PARASITES, (Plasmodium falciparum)
C1 Schizonts.
C2 Gametes ♀
♂
J. Carroll '18

Fig. 4.—Malarial Parasites.

Benign Tertian Parasites.

A1. Schizonts. (1)Normal red cell. (2) Young ring form. (3) Amœboid showing Schuffner's dots. (4) Amœboid form showing increased chromatin (twenty-four to thirty hours). (5) Segmentation of nucleus. (6) Nuclear halves further apart, red cells enlarged and pale. (7) Further division of nucleus. (8) Unusual division form. (9) Typical merocyte. (10) Rupture of merocyte liberating merozoites.

A2. Female gametes. (1) Young form showing solid instead of ring-form staining. (2) Half-grown form. (3) Rapidly growing form with compact nucleus and clear vacuolated zone. (4) Full-grown macrogamete showing excentrically placed chromatin and much pigment in deep blue stained protoplasm. Male gametes. (1) Young form similar to female one. (2) Half-grown form showing central chromatin. (3) Full-grown microgametocyte showing large amount of centrally placed chromatin with light blue protoplasm surrounding. (4) Division of chromatin occurring in microgametocyte and developing in wet preparation. The Chromatin division in gametes does not take place until blood is withdrawn. (5) Spermatozoön like microgametes developing from the microgametocyte. This only occurs in wet preparations or in the stomach of the mosquito.

Quartan Parasites

B1. Schizonts. (1) Normal red cell. (2) Young ring form. (3) Older ring form. (4) Narrow equatorial band. (5) Typical band form. (6) Oval form showing division of chromatin. (7) Early stage merocyte. (8) Daisy form merocyte.

B2. Male gametes. (1) Young solid form. (2, 3 and 4) Developmental stages microgametocytes. (5) Flagellated body in wet preparation showing microgametes developing from microgametocytes. Female gametes. (1) Young ring form. (2) Somewhat older stage. (3 and 4) Mature macrogametocytes (same as benign tertian).

Malignant Tertian Parasites.

C1. Schizonts. (1) Normal red cell. (2, 3, 4, 5 and 6) Young ring forms. These are hair-like rings and are the only forms besides crescents to be found in the peripheral blood. In very heavy infections or in smears from spleen the following forms are found. (7) Beginning division of chromatin. (8 and 9) Further division. (10) Merocyte.

C2. Female gametes. (1 and 2) Young macrogametes. (3) Older stage. (4) Development in red cell. (5 and 6) Fully developed female crescents showing clumping of pigment and rich blue color. Male gametes. (1 and 2) Developing forms. (3 and 4) Fully developed microgametocytes. (5) Flagellated body developed in wet preparation. (*Stitt, Practical Bacteriology, Blood Work and Animal Parasitology, 5th Edition, P. Blakiston's Son & Co.*)

At some time of its life almost every protozoan exhibits movement of some kind. The Rhizopoda with soft ectosarcs move either by pseudopodia or else roll over and over by a continuous flowing of the upper surface of the soft ectoplasm. The Mastigophora are provided with whip-like flagella, usually projecting anteriorly, which propel the cell in a manner not unlike the tractor of an aeroplane; others, laterally arranged, have an oar-like motion. The Sporozoa, as a class, move very little, but their sporozoites are motile. The movements of Infusoria are caused by cilia. In some classes cilia also encircle the oral aperture and aid the Protozoa in securing food.

The size of Protozoa varies from those so small that they can pass slowly through a Berkefeld filter (treponema), to the sarcosporidium which may be seen with the naked eye and the non-pathogenic myxosporidia which may be an inch in diameter.

Protozoa reproduce asexually (schizogony), by one of the following methods: (1) Binary fission; (2) spore formation; (3) gemmation. They also undergo sexual reproduction (sporogony), or simple rejuvenescence by conjugation. Recent close study has shown that most forms are subject to at least occasional conjugation.

Most Protozoa are capable at times of encystment for self-preservation. This may occur in the spore stage (coccidium), or in the adult stage (ameba). Encysted Protozoa have not the same resistance to high temperatures possessed by bacterial and other plant spores, with which they are analogous.

Subkingdom II, **Metazoa**

Definition. Metazoa are multicellular animals, free-living or parasitic, characterized by a physiological division of labor among their cells.

Parasitic Metazoa may be ectoparasites—as are many of the Insecta—or endoparasites, for example, many of the worms. Ectoparasites may cause disease by introducing into the tissues bacteria, toxins, and protozoa. They are of great importance in preventive medicine. Diseases are often limited to the regions infested by the disease-spreading parasites; for example, yellow fever is confined to the districts inhabited by the mosquito *Aëdes calopus*. The ill effects produced on the host of metazoan parasites depend upon the following conditions: number of parasites, species, their condition, organs infested, migration in the body, condition of the host, and loss to the host in nourishing the parasites.

Platyhelmia (*Flat Worms*). Bilaterally symmetrical worms with a blade or tape-like, rarely cylindrical body, which is either covered with ciliated epithelium (Turbellaria), or with a cuticle the subcuticular layer of which is sunk into the parenchyma (Cestodes, Trematodes). They possess a well-developed musculo-dermal layer, but no cœlom. The mouth is generally at the anterior end of the body, but it may be situated on the ventral surface, further back. There is a pharynx and branched mid-gut, but no hind-gut or anus. The alimentary canal is lacking in the Cestoda. The excretory system begins in ciliated cells from which fine channels run, uniting into larger channels. These finally empty into two laterally placed canals, which, sometimes separately and sometimes unitedly, open to the exterior through one or several excretory vesicles.

The nervous system is embedded in the parenchyma and consists of a dumb-bell shaped ganglion and several medullary fasciculi running forward and backward, and often forming anastomoses. Simple eyespots sometimes occur and in a few species an auditory vesicle. Blood vessels and definite respiratory organs are lacking except in Nemertinea.

Most of the Platyhelmia are hermaphroditic, but a few are unisexual. In most of the species the female genital apparatus is provided with a yolk in addition to the ovaries. This provides nourishment for the fertilized ova, which, after obtaining shells from the shell gland, enter a uterus and are slowly discharged to the exterior. The male generative organs consist of testes, vasa deferentia, vesicula seminalis, cirrus pouch with a cirrus and a rudimentary prostate gland. The two sexual openings usually lie close together, as a rule in the base of a genital atrium. Reproduction is sexual, but is often combined with asexual methods (segmentation and budding).

The greater part of the members of this phylum live as parasites on or in other animals. Some species live free in fresh or salt water, a few on land.

Classification. The Platyhelmia include the following classes:

Class I. **Turbellaria.** Flat worms, free living, usually leaf-shaped or oval, always covered with ciliated epithelium. They live in fresh or salt water or on land; very seldom parasitic.

Class II. **Trematoda.** Sucking worms, usually known as flukes, leaf-like or tongue-shaped, rarely cylindrical. The mouth and alimentary canal are retained, ciliated in the larval stage only. The epidermis sinks into the mesoblast after secreting a chitinous cuticle. They are provided with oral and ventral suckers. There is generally an alternation of generations, one sexual generation being followed by one asexual one. They are almost without exception parasites of vertebrate animals. The intermediary generations are passed in molluscs.

Class III. **Cestoidea** (*Tapeworms*). Endoparasitic flat worms without an alimentary canal in any stage of their life cycle. The body is either simple or composed of a chain of segments or proglottides. In the latter instance it consists of the scolex and the segments containing the sexual organs. The head and neck together form the scolex. The larva are rarely ciliated, but are usually armed with six hooklets. The adult is covered with a cuticle, the matrix of which is sunk into the parenchyma. Lime-secreting cells form calcareous concretions in the parenchyma. The scolex has sucking and clinging organs of variable character and contains the central nervous system and the commencement of the water-vascular system. The excretory organs are symmetrical and open at the posterior end.

The Cestoidea are nearly always hermaphroditic and possess one or two female and one male sexual orifice. A phase of development is a larval intermediary stage termed "cysticercus," which almost always lives as the sexual animal in another host. The adult stage is most frequently parasitic in vertebrates and the larval stage in invertebrates. The adult normally inhabits the intestine, the larva some other part of the body.

TREMATODES OR FLUKES.

Faciola hepatica
Fascioletta ilocano
Fasciolopsis buski
Dicrocœlium lanceatum
Paragonimus westermani
Opisthorchis felineus
Clonorchis sinensis
Clonorchis endemicus
Heterophyes heterophyes
Cladorchis watsoni
Gastrodiscus hominis
Schistosoma hæmotobium
Schistosoma japonicum
Schistosoma mansoni

CESTODES OR TAPEWORMS.

Dibothriocephalus latus
Diplogonoporus grandis
Dipylidium caninum
Hymenolepis diminuta
Tænia solium
Tænia saginata
Davinea madagascarensis

The above Platyhelminthes or flat worms are found in man. In addition to the above two larval Tæniidæ (*Cysticercus cellulosæ* and *Echinococcus polymorphus*) and two larval Dibothriocephalidæ (*Sparganum mansoni* and *Sparganum prolifer*) infest man.

Nemathelmia (*Round Worms*). Tubular or filiform unsegmented worms covered with a cuticle which is frequently ringed and is as a rule developed in four ridges. They have no limbs, but are usually provided with bristles, hooks, papillæ or rarely suckers. There is no closed vascular system and no respiratory organs. The alimentary canal is tube-like in appearance and has near the mouth a muscular esophagus. The sexes are separate; the testes and ovary are generally tube-like. The male is smaller and in some species has an umbrella-like expansion, the copulatory bursa. The genital opening of the male is near the anus, that of the female about the middle of the ventral surface. Most of the Nemathelminthes are oviparous and develop as larvæ from the eggs in damp earth. Very few species are viviparous. They are usually parasitic during some part of their life-cycle. The adult develops in a different host from that infested by the larvæ. The adult may be free and the larvæ parasitic or vice versa.

The Nemathelminthes are important in preventive medicine, and especially so in tropical medicine, as they include *Achylostoma duodenale* and the Filariidæ, the causes of great morbidity in the tropics and subtropics.

Classification. The Nemathelminthes are divided into two classes:

Class I. Complete or rudimentary intestine; no armed proboscis. Order I. *Nematoda.* Order II. *Gordiacea.*

Class II. Intestine absent; anterior end provided with an armed proboscis. Order III. *Acanthocephala.*

Nematoda. White, filiform Nemathelminthes, parasitic as a rule, but minute forms occur in moist earth in most parts of the world. The worm is encased in a smooth or ringed, thick or transparent cuticle which may form lateral fins, hooks, or spines. Under the epidermis which underlies the cuticle is a peculiar muscular layer cut into four quadrants by thickenings of the epidermis. These project inward and delimit ventrally a nerve cord and laterally an excretory channel. The undivided body cavity, not a true cœlom, is under the skin and contains a fluid that may be analogous to the lymph and blood of higher organisms. The digestive system comprises a mouth, situated at the anterior end and surrounded by two to six lips, which leads into a suctorial esophagus lined with chitin; this in turn opens into a flattened intestine leading to a short rectum ending in an anus. The lateral excretory tubes unite anteriorly and open just behind the mouth, in the mid-ventral line. The nervous system consists of a nerve ring around the esophagus, with anterior and posterior nerve trunks.

The sexes are separate. The male reproductive organs consist of a single tube divided into testes, vas deferens, vesicula seminalis, and ductus ejaculatorius. This opens on the ventral surface of the rectum, close to the anus. Certain spines and papillæ at the posterior end are modified for sexual purposes. The female reproductive organs are two coiled tubes divided into ovary, oviduct, and uterus. These unite to form the vagina, which opens just in front of the anus, or in the middle of the body in the mid-ventral line.

The nematoda generally inhabit the intestine and live upon the intestinal contents. Some enter the villi of the intestine.

The following Nemathelminthes or round worms are of interest in medicine:

ACANTHOCEPHALI.

Gigantorhynchus gigas

NEMATODA.

Strongyloides stercoralis
Dracunculus medinensis
Filaria bancrofti
Filaria loa
Filaria perstans
Filaria demarquayi
Filaria ozzardi
Filaria philippensis
Onchocera volvulus
Trichuris trichura
Trichinella spiralis
Eustrongylus gigas
Strongylus apri
Trichostrongylus instabilis
Tridontophorus deminutus
Œsophagostoma brumpti
Physalostoma caucasica
Achylostoma duodenale
Necator americanus
Ascaris lumbricoides
Belascaris mystax
Oxyuris vermicularis

Annulata. Metazoa divided into segments or metameres which show externally as rings. The body is usually elongated and contains an extensive cœlom. A cerebral ganglion with commissure and ventral nerve cord constitute the nervous system. The nephridia, or organs of excretion, are placed metamerically in pairs.

Hirudinea or Discophora (*Leeches*). Annulata with oval-shaped dorso-ventrally flattened bodies having a sucker at each end. The body is retractile and extensile.

The following are the important species: *Hirudo medicinalis, Limnatis nilotica, Hæmadipsa ceylonica.*

Arthropoda. (*Jointed-limbed Animals*).—Crustaceans and Insects. The members of this phylum have jointed appendages, i. e., antennæ, jaws, maxillæ (or accessory jaws), palpi and legs arranged in pairs and penetrated by blood spaces. The body is heteronymously segmented and contains a well-developed cavity. Most genera have the skin hardened by the deposition of salts, carbonate and phosphate of lime, and by chitin, an organic substance. The segments are uniform in certain regions but differ from those of contiguous regions, so that it is possible to distinguish head, thorax, and abdomen, each composed of segments. The head is well marked, with one or two pairs of feelers or antennæ and from two to four pairs of biting mouth-parts or jaws. There are two compound eyes, and the insects also have simple eyes. There is usually a well-marked metamorphosis. Within the chitinous exoskeleton is a dorsal digestive system and a ventral nervous system. Respiration takes place by gills in the Crustacea and by tracheal tubes in the Myriapoda, Arachnoidea, and Insecta.

The Arthropoda resemble the segmented worms, but differ from them in having jointed appendages proceeding from the segments in pairs. Some of the pairs are for locomotion; in some genera certain ones are specialized for grasping food.

Arachnida (*Spiders, Mites, etc.*). The Arachnida are divided into two regions, a head-thorax and abdomen. The head and thorax are fused together. There are no antennæ, only a pair of mandibles and a pair of maxillæ, with four pairs of legs, the Insecta having only three pairs. There are never any compound eyes; when eyes are present they are always simple. The young usually resemble the adult; in the mite there is a slight metamorphosis.

Acarina. In the acarines there is no separation of the abdomen from the cephalo-thorax. There is a slight metamorphosis from a hexapod larva hatched from the egg to an octopod, sexless nymph. The fully developed acarine has, in addition to the four pairs of legs, two other pairs of appendages, the cheliceræ in front of the mouth and the pedipalps on either side of the mouth.

The Acarina include the mites and ticks, and disseminate disease among both men and animals. In man they spread relapsing fever and Rocky Mountain fever. They are also responsible for some skin diseases, scabies among others. In man they cause some forms of dermatitis and spread Babesiasis and some Spirochætiases (Texas cattle fever).

Ixodoïdea (*Ticks*). Acarines with leathery skin, comparatively large; body flattened, but abdomen spherical after sucking blood; rod-like cheliceræ with serrated, unciform terminal joints. A rostrum with barbed hooks is formed by the median parts of the pedipalpi (maxillæ). The maxillary palpi are rounded or club-like; the legs are composed of six segments with two terminal ungues, frequently provided with sucking disks. The stigmata are at the sides of the body, posterior to the fourth pair of legs. The larvæ are six legged.

Life History. The life history and habits of the Ixodidæ differ with the different divisions of the family, but the following is a brief summary:

The male and female copulate while on the host sucking blood. The female, after attaining a large size, drops to the ground and lays eggs, some of the Ixodinæ as many as 20,000. The egg consists of shell, inner membrane, food-yolk, and embryo. The embryo hatches as a six-legged larva without sexual organs or stigmata, but with digestive organs. The eggs are preferably deposited near grass. The six-legged larva or "seed tick" emerges from the egg in from two to six months, crawls up a blade of grass, becomes parasitic on some passing animal, sucks its blood, drops off, molts, and becomes the nympha. The nymphæ are without sexual organs or openings, have eight legs and a pair of large stigmata. They also crawl up blades of grass and get on passing animals (the second host). After feeding they fall to the ground and remain eight or ten weeks. After molting again they develop into adult ticks, males and females, with fully developed reproductive organs. The adults now gain access to a third animal host, the female fixes itself to the host, increases in size, but rarely changes her position; the male remains small and moves about looking for the female. Some ticks require fewer hosts.

Insecta (*Hexapoda*). This class has one pair of antennæ, three pairs of mouth-parts, and three pairs of legs. The body is divided into head, thorax, and abdomen. The antennæ and mouth-parts are on the head; the thorax, divided into pro-, meso- and meta-thorax, has a pair of legs upon the ventral surface of each segment, and a pair of wings upon the dorsal surface of the two posterior segments. The abdomen has no appendages. Respiration is by means of tracheæ, opening by means of stigmata. The excretory organs are part of the alimentary system. The Insecta have two pairs of wings, but the second pair is frequently rudimentary, showing as knob-like eminences. In the Siphonaptera both pairs of wings are rudimentary.

Where metamorphosis occurs, worm-like larvæ are hatched from eggs; these change into quiescent, non-feeding, encased pupæ, which in turn develop into the imago or adult insect. Some insects have only an incomplete metamorphosis, lacking some phases of the developmental cycle.

Siphunculata, Rhynchota, Siphonaptera, and Diptera are the only orders of importance in medicine.

Siphunculata. Hexapoda with dorso-ventrally flattened bodies. Labium and labrum fused to form a proboscis or rostrum containing a hollow, extensile sucker formed by the mandibles and maxillæ, and armed with recurved hooklets. The antennæ are five-jointed and the eyes have no facets. Thorax is slightly segmented and wings are absent. Terminal joints of legs are hook-like and adapted to clinging. The posterior abdominal segment is rounded in the male and notched in the female. Metamorphosis is incomplete.

Pediculidæ (*Lice*). Wingless insects showing no metamorphosis, the young resemble the adults and are hatched from acorn-shaped eggs (nits) deposited on clothing or hairs of the host. The eyes are simple, antennæ five-jointed, legs well developed, terminating in powerful claws. There are several generations each year, the number influenced by the temperature. The life history of none of the species is well understood.

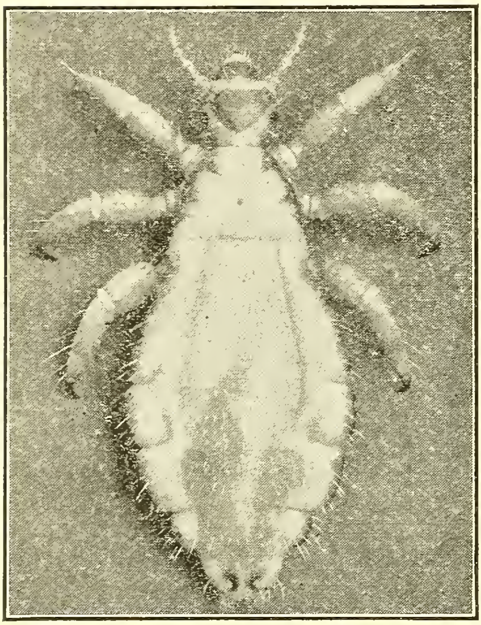


Fig. 5.—Body Louse. *Pediculus vestimenti.* (*American Museum of Natural History, New York.*)

Pediculus humanus capitis. Female about 2 mm. long; male smaller. Eggs about 60 in number, deposited on hair of the head; hatch in about six days. The male louse is rounded off posteriorly and shows a dorsal aperture for a pointed penis, while the female is recognized by a deep notch at the apex of the last abdominal segment. The thorax is as broad as the abdomen. The head lice vary in color according to the color of the hair of the host, and show a marked preference for their own peculiar racial host.

Pediculus humanus corporis or vestimenti. (''Gray-back''—American Civil War; ''Cootie''—Great War). Head somewhat rounded; abdomen broader than thorax; whitish-gray in color; 2-4 mm. in length; antennæ longer than the head louse. About seventy-five eggs are deposited and hatch out in seven to ten days when on clothing worn next the body and become mature in about two weeks. The mature female deposits these eggs to the number of four or five daily so that in her average life of four or five weeks she lays the number noted above. Feeding takes place about twice daily and

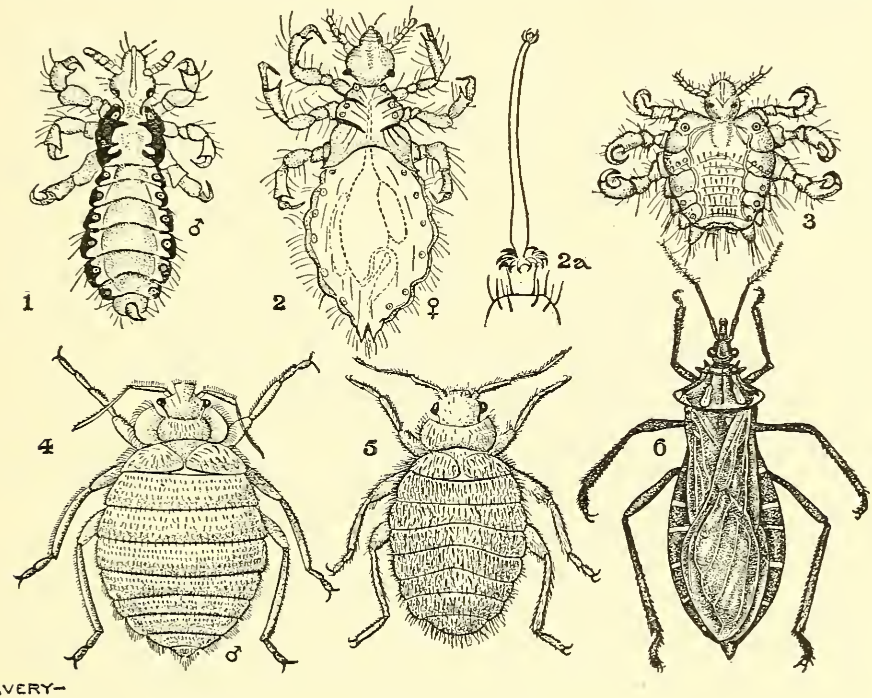


FIG. 6.—SIPHUNCULATA AND RHYNCHOTA.

(1) *Pediculus capitis.* (2) *Pediculus vestimenti.* (2a) Protruded rostrum of *Pediculus.* (3) *Phthirius pubis.* (4) *Acanthia lectularia.* (5) *Acanthia rotundata.* (6) *Conorhinus megistus.* (*Stitt, Practical Bacteriology, Blood Work and Animal Parasitology, 5th Edition. P. Blakiston's Son & Co.*)

deprivation of food will kill the adult in five days. The newly hatched louse will die in four days if unfed. Pediculus vestimenti lives about the neck and trunk underclothing and deposits its eggs in the clothing, generally in the seams. The females do not begin to oviposit for three or four days after reaching maturity and before doing so must feed. If they experience a temperature below 65° F. they will not oviposit. (Stitt).

Phthirius pubis or pediculus pubis, the crab louse. Male 0.8—1.0 in length; female 1.12 mm. in length, color grayish-white; form almost square. The two posterior pairs of legs are strong and supplied with formidable hooks. The female lays about a dozen eggs which hatch out in about a week.

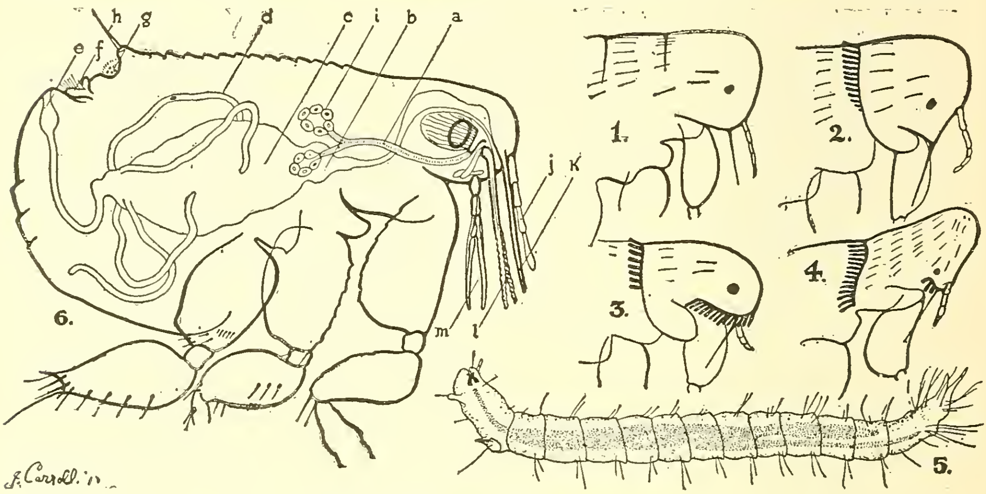


FIG. 7.—SPECIES OF FLEAS.

(1) *Xenopsylla cheopis.* (2) *Ceratophyllus fasciatus.* (3) *Ctenocephalus felis.* (4) *Ctenopsylla musculi.* (5) Flea larva. (6) Internal anatomy of flea: (a) salivary duct; (b) proventriculus; (c) stomach; (d) malpighian tubules; (e) rectum; (f) claspers; (g) pygidium; (h) antipygidial bristles; (i) salivary ducts; (j) maxillary palps; (k) epipharynx; (l) mandibles; (m) labial palps. (*Stitt, Practical Bacteriology, Blood Work and Animal Parasitology, 5th Edition. P. Blakiston's Son & Co.*)

The pubic region is its favorite place of abode. *Phthirius pubis* is found almost exclusively in the Caucasian race.

Rhynchota. (*Hemiptera*). Insects having a sucking beak, a long, thin tube or rostrum formed by the lower lip. This bends under the head or thorax. The mandibles and maxillæ are inside the beak. There are no palpi. Metamorphosis is incomplete.

Acanthiidæ. Flattened body; rostrum three-jointed; antennæ four-jointed; wings atrophied.

Reduviidæ. Rhynchota with long, narrow heads; distinct neck; eyes large and permanent; proboscis short, thick, and curved; antennæ long and slender.

Siphonaptera. Insects with laterally compressed bodies and distinctly separated thoracic rings; markedly chitinized; wingless; antennæ three-jointed and embedded in grooves. Metamorphosis incomplete.

Pulicidæ. Siphonaptera with body compressed or elongated; head relatively small with rounded top and frequently no eyes. The antennal groove is sometimes protected by a chitinous plate; thorax wide. "Combs," important in classification, may or may not be present.

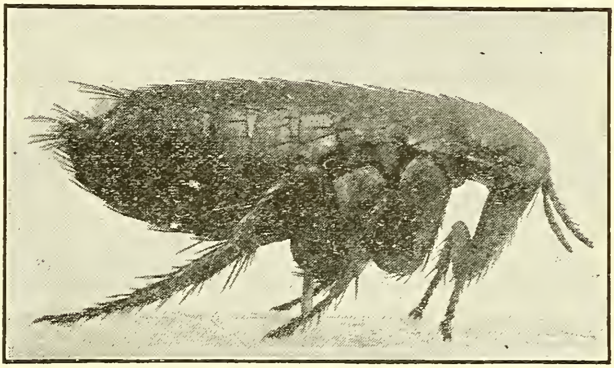


Fig. 8.—Model of Rat Flea. *Ceratophyllus fasciatus.* (*American Museum of Natural History, New York.*)

This family, the fleas, are important in preventive medicine, as they transmit plague.

Pulicinæ. Little change in form in female after fecundation; freedom of movement retained.

Sarcopsyllinæ. Abdomen of female enormously distended with eggs after fecundation; female burrows under skin and remains fixed.

Life History of Pulicidæ. Fleas are hatched from the eggs in the dust of crevices, etc., as bristled larvæ in about one week. The larva forms a cocoon and changes into a nymph with three pairs of legs. The nymph develops into the adult flea and emerges from the cocoon in about three weeks.

Diptera. Insects with two well-developed transparent wings and two rudimentary wings; mouth-parts well developed and adapted for sucking, puncturing, or licking. Metamorphosis includes larva, pupa, and imago, and is complete.

The members of this order are of great importance medically in a number of ways. They cause irritation by their bites; they transmit disease directly—for example, typhoid fever by Musca domestica; and they act as intermediate and definite hosts for various protozoan parasites.

Suborder: **Orthorrhapha.** Larva with distinct head; no lunula or ptilinum; imago escapes from larval or pupal case by T-shaped opening.

Section I. Nematacera. Long, many-jointed antennæ.

Families: Simuliidæ, Psychodidæ, Culicidæ, etc.

Section II. Brachycera. Short antennæ.

Families: Tabanidæ, etc.

Suborder: **Cyclorrhapha.** Larva without distinct head; adult escapes through anterior opening and has a lunula and usually a ptilinum.

Families: Muscidæ, etc.

Suborder: **Pupipara.** The fully developed larvæ are extruded directly from the imago and almost immediately begin the pupal life without a free-living egg stage. The wings are poorly developed. Parasitic on vertebrates.

Families: Hippoboscidæ, etc.

Simuliidæ. No transverse sutures on thorax; no ocelli; short legs with posterior tibiæ and first joint of hind tarsi dilated; antennæ short, straight, cylindrical, eleven-jointed and without setæ; eyes of male large, meeting in middle line; those of the female smaller and separate.

Psychodidæ. (Moth Midges). Body covered with coarse hairs; no ocelli; thorax without transverse suture; wings hairy and very broad; no discoidal cell; antennæ long, with sixteen joints; legs long, no spurs on tibiæ.

Chironomidæ. (Midges). Very small and with relatively small head, often retracted under the thorax; antennæ with from six to fifteen joints; eyes reniform; ocelli absent; wings shorter than the abdomen and have longitudinal veins.

The three foregoing families are blood-sucking Diptera and are frequently mistaken for mosquitoes. None of them have scales on their wings.

Culicidæ. (Mosquitoes). Body more or less covered with scales and hairs; long, piercing proboscis; antennæ with whorls of plumes or hairs, frequently dense and long in the male but scanty in the female. The wings have six or seven longitudinal veins with two fork cells and scales; costa has scales and forms fringe around the wing. Metamorphosis is complete.

Culicinæ. Culicidæ with long palpi in the male, short in the female; straight proboscis; postscutellum nude; wings without a third anal vein, first marginal cell long; larvæ have respiratory siphons.

Stegomyia. Culicinæ with head and scutellum covered with flat scales.

Stegomyia calopus (*Aëdes*). Tiger mosquito, spreads yellow fever; bites chiefly in the afternoon; can easily live aboard ship, hence carried to many parts of the world.

Anophelinæ. Culicidæ with long palpi in both sexes; straight proboscis; frequently upright forked scales on occiput, never flat scales; thorax with hair or scales; postscutellum nude; eggs laid singly, not in rafts; larvæ without respiratory siphon.

Differences between the Anophelinæ and the Culicinæ. The Anophelinæ generally project from a plane surface upon which they are resting at a sharp angle, as their head, thorax, and abdomen form a more or less straight line; the Culicinæ do not make such a well-defined angle, as the abdomen is not in the same straight line as the long axis of the thorax. The eggs of the Anophelinæ are laid singly, those of the Culicinæ in rafts. The larvæ of the Anophelinæ have no drawn-out siphons, hence lie more or less parallel to the surface of the water; the larvæ of the Culicinæ hang downward. There are a few exceptions to these rules.

Life History of the Mosquito. The mosquito passes through a complete metamorphosis, consisting of egg, larval, and pupal stages, finally developing into the adult insect, or imago. This occupies about two weeks.

The eggs are laid upon the surface of the water. The Anophelinæ eggs are laid singly in triangle, star, and ribbon patterns. They are oval in shape and have air-cell projections at either end. The eggs of Culex are arranged vertically in black, scooped-out, raft-like masses; those of Stegomyia are laid singly and are surrounded by fringe like a pearl necklace. The duration of the egg stage varies with the temperature and other conditions, two to four days for Anophelinæ and one to three days for Stegomyia. The larvæ are legless creatures, usually called "wrigglers." They have flattened heads, rectangular or trapeziform thorax with bristles, and a segmented abdomen with lateral bristles.

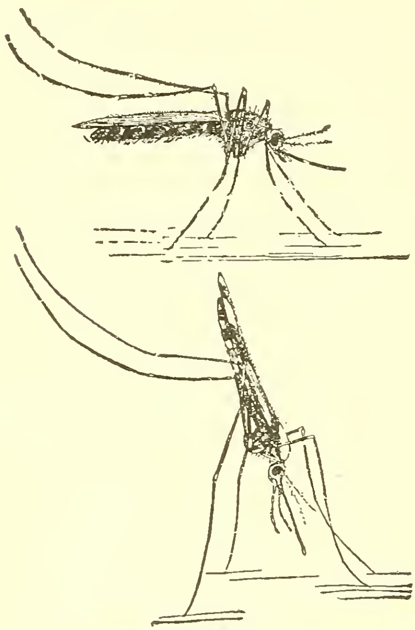


Fig. 9.—Mosquito.
Culex Adult (Above). *Anopheles* Adult (below). (*American Museum of Natural History, New York.*)

The breathing stigmata are at the posterior end of the dorsal surface; in Culicinæ larvæ, however, they are on the free end of a long projecting tube called a respiratory siphon. This projects at an angle from the axis of the body and terminates in four flap-like paddles. The siphon of Culex is long and slender, that of Stegomyia short and barrel-shaped. The Culex larvæ hang from the water at an angle of about 45° and the siphon is almost vertical. Stegomyia larvæ hang more vertically. Anophelinæ larvæ are darker in color, have no siphon, and float parallel to the surface of the water. The duration of the larval stage varies with the temperature, from one to two weeks.

The pupa have a bulky cephalo-thorax and a segmented, tail-like abdomen. They somewhat resemble tadpoles. On the dorsal surface are small breathing siphons. In Culex these are long and slender and project from the posterior part of

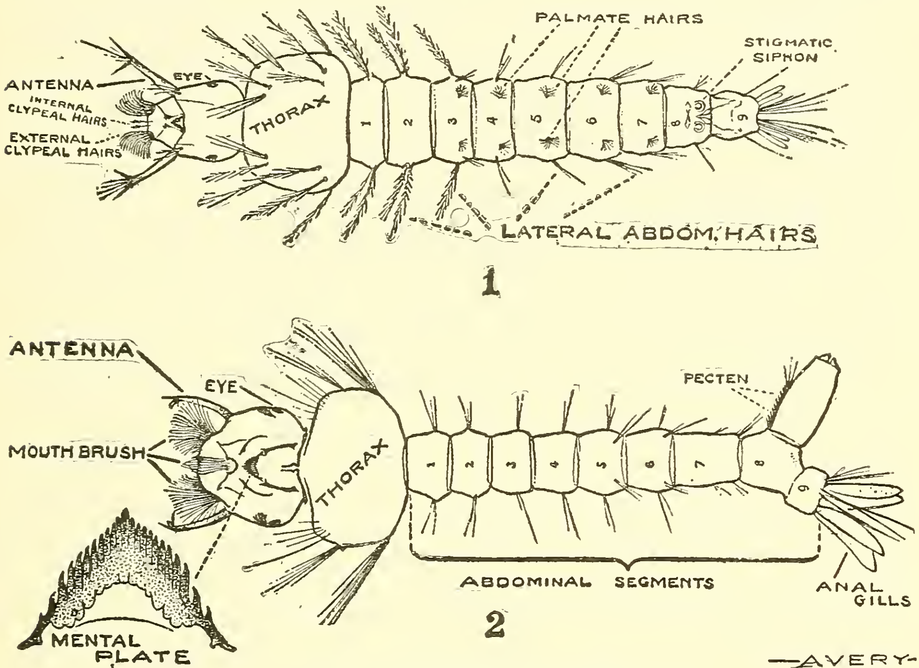


Fig. 10.—Mosquito Larvæ.

(1) Asiphonate larva. *Anopheles.* (2) Siphonate larva. *Stegomyia.* (*Stitt, Practical Bacteriology, Blood Work and Animal Parasitology,* 5th *Edition. P. Blakiston's Son & Co.*)

the cephalo-thorax; in the Anophelinæ they are funnel-shaped and project from the middle of the cephalo-thorax; in Stegomyia they are triangular in shape. Pupæ do not feed. The imago hatches in three or four days. It floats for a time on the pupal skin until its wings are dried and its chitinous integument and then flies away.

The adult insect is hatched from the pupa in the afternoon and is then ready for fecundation by the male. During the breeding season but few females are seen. Only the female bites man and animals. This is probably to obtain nourishment for the eggs. The male lives on the juice of plants and fruits. The female also feeds upon vegetable juices. The female mouth-parts are adapted for piercing; those of the male are not.

The female anopheline mosquito infects the bitten animal with malaria during the act of biting. The sporozoites pass down the hypopharyngeal or salivary tube. Infection of the mosquito occurs through the blood of the animal passing into the mouth of the mosquito *via* the labial or blood tube.

Mosquitoes usually bite at night, preferably in the dark. After feeding they generally retire to dark places to digest their food. The female lays her eggs in the early morning in nearest available water. It is assumed that she can fly about half a mile for that purpose. Culicinæ will utilize almost any water in which to lay their eggs, but the Anophelinæ select clean water containing vegetation.

Mosquitoes can hibernate during the cold months of the temperature zones and æstivate during the hot season of the tropics. In the latter condition they bite animals and suck blood, but apparently do not lay eggs, even though water be available.

Mosquito eggs float upon the surface of the water. The larvæ live upon algæ and diatoms and are likewise cannibals. To breathe they must come to the surface of the water. Anophelinæ larvæ, asiphonate, have to lie parallel with the surface to allow the air to enter the spiracles. Culicinæ larvæ are siphonate and merely bring the free end of the siphon to the surface of the water. Larvæ and possibly eggs hibernate.

Tabanidæ. Insects with heavy-set bodies and frequently large heads; antennæ with three segments; eyes, usually brilliant in color, meet in the males but separate in the females; proboscis prominent and strong; wings with large basal cells and five posterior cells; legs fairly stout. The eggs are laid on the leaves and stems of plants near swampy places. The larvæ are carnivorous.

This family are blood-sucking flies, but the habit is confined to the females. The males live on plant juices. They are known as horseflies, gadflies, breeze flies, green-headed flies, etc., and are found throughout the world.

Muscidæ. Flies with short thoraces and heavy bodies; arista either entirely plumose or pectinated; first posterior cell of wing is closed at the border or slightly opened. The proboscis of Glossina and Stomoxys is elongated and adapted for biting; in Musca, Calliphora, Lucilla, and Chrysomia the proboscis is not adapted for biting.

Glossina. Dull-colored flies, yellowish-brown or grayish-brown; wings project beyond the abdomen and overlap when closed; proboscis has bulbous base and projects anteriorly, ensheathing the palpi, which extend slightly beyond.

Life History of the Glossina. The Glossina live in jungles, near streams or lakes. They apparently live principally upon the blood of big game. It has been stated that Glossina palpalis feeds on the blood of the crocodile, and also that of the hippopotamus. The female lays one motile larva, almost as large as the mother; sometimes another after about two weeks. The larvæ are yellow, and have twelve segments with two anterior mouthhooks. They bore into a hole in a coarse, sandy soil, frequently near the roots of banana trees, and become black pupæ in a few hours. The fully developed insect emerges in about six weeks.

Dry, loose soil and shade are necessary for the development of the larvæ; moisture and sunlight kill them. Attempts have been made to exterminate the genus by cutting down the trees, but without success, as the secondary growth which soon springs up provides the necessary shade for the protection of the pupæ. Trees alone will not protect the fly unless they overhang the water or their foliage mixes with the undergrowth of the jungle.

The flies do not travel great distances from their breeding places by flight, but can be carried almost any distance by boats and floating islands of papyrus. Females fly further in search of food than males, as their need is greater.

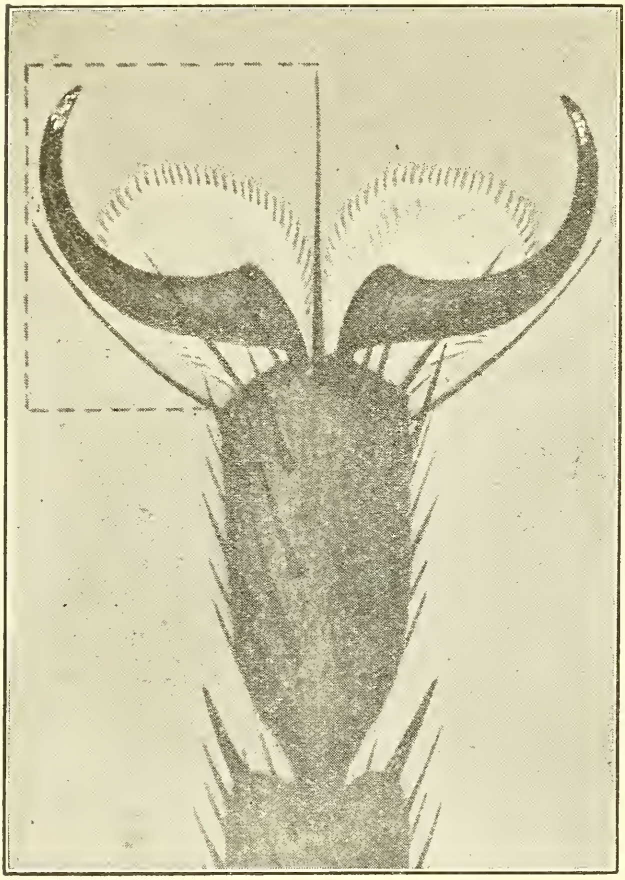


Fig. 11.—Lower Joint of the Foot of the Fly Magnified 160 Diameters. (*American Museum of Natural History, N. Y.*)

Glossina bite mostly between 9 A. M. and 4 P. M., and will bite in bright sunlight. Both males and females bite and transmit disease.

Glossina palpalis and *Glossina morsitans* are tsetse flies, and transmit human trypanosomiasis, the African "sleepingsickness."

Musca. Lower part of face yellow, mottled with blackish - brown; antennæ brown; median stripe black; four longitudinal stripes on gray thorax; abdomen yellowish; scutellum gray with black sides; wings pale gray with yellow base; legs black-brown; eyes close together in male, separate in female.

Life History of Musca Domestica. Most of the house flies die in the early autumn, many being killed by a fungous disease due to *Empusa muscæ,* then prevalent among them. A few adults survive the winter in secluded places such as attics, cellars, stables, etc. With the return of warm weather they lay their eggs, generally about 125, preferably in fermenting horse manure. The eggs hatch into larvæ, called

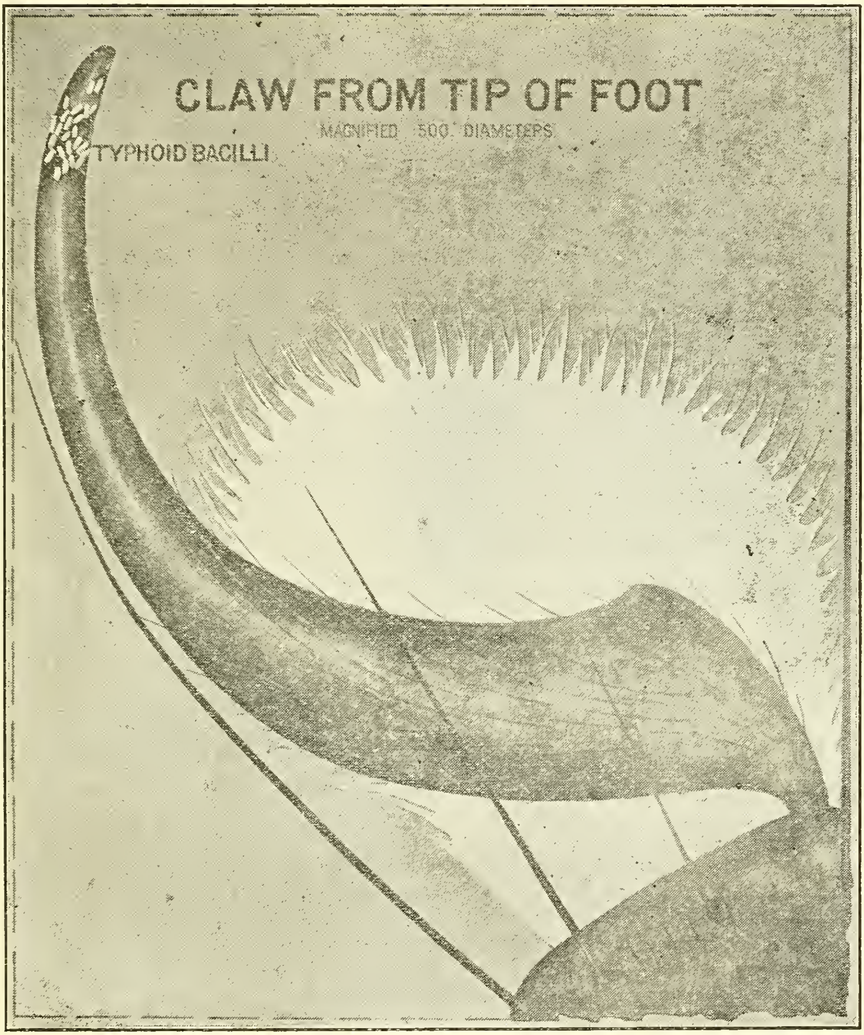


FIG. 12.—THE FOOT OF THE COMMON HOUSE FLY (*Musca domestica*) MAGNIFIED 500 DIAMETERS.

maggots, in six to eight hours; these are fully developed in four or five days. The larva then changes into a coarctate pupa contained in the puparium, a hard, brown case formed by its old skin. The adult fly emerges in from three to five days.

The time required for development from larva to imago is never less than eight days, and may be much longer, depending upon the temperature of the air. It is most rapid between 22° and 35° C. Moisture and fermentation are also necessary. In view of this fact it is self-evident that manure and all organic refuse should be removed at least as often as every ten days to prevent the development of flies.

While flies breed by preference in horse manure, they will

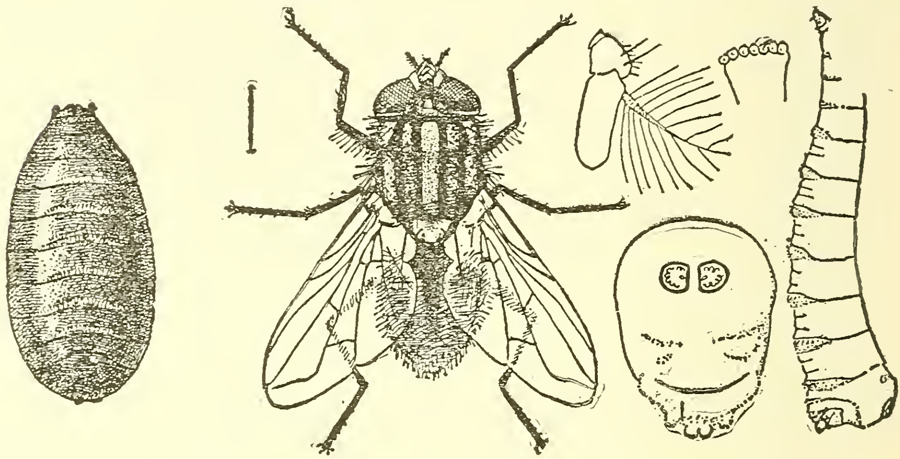


Fig. 13.—Common House Fly (*Musca domestica*).

Puparium at left; adult next; larva and enlarged parts at right. All enlarged. (*Circular No. 71, Bureau of Entomology, United States Department of Agriculture.*)

breed in garbage and organic matter of all kinds, such as putrefying animal and vegetable matter, carcasses of various animals, the bedding in chicken coops, in refuse hog hair, in tallow vats, and in human excrement. The accumulation of organic waste is followed by the appearance of flies.

Three or four days before pupation the maggots have a tendency to migrate from their birthplaces. They burrow into the loose soil beneath the manure piles or crawl under stones, boards, dry manure, etc., seeking dark, dry places. The winged insect, on emergence from the puparium, is thus enabled easily to reach the open air. Manure piles may be moistened and the escaping maggots caught in boxes or baskets and destroyed.[1]

Musca domestica is incapable of biting, as the piercing organs are fused with the labium. They transmit disease directly in a mechanical manner by carrying infectious material from the source, as feces, to food or exposed surfaces, as the conjunctiva.

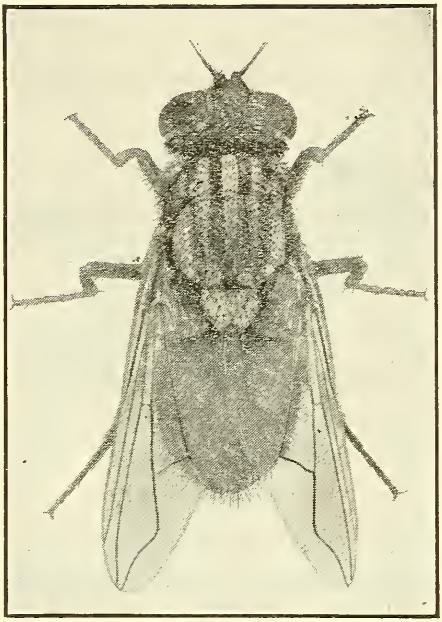


Fig. 14.—Common House Fly or Filth Fly. *Musca Domestica.* (*American Museum of Natural History, New York.*)

The life history of *Stomoxys calcitrans,* the stable fly, is very similar to that of *Musca domestica,* but it develops more slowly, requiring nearly a month for complete metamorphosis. The same breeding places are utilized, but more frequent use is made of cow manure, fermenting piles of grass, and the refuse from breweries. The adult resembles the house fly, but the sharp proboscis is adapted for biting. The food of the stable fly is exclusively mammalian blood. They are very troublesome to livestock in late summer and early autumn. They occasionally bite human beings, and there is the possibility of their being one of the transmitting agents of poliomyelitis. They also transmit disease germs mechanically in the same manner as the house fly.

Sarcophagidæ. Bodies usually thick-set and moderately large; antennal bristles feathery at the base, but hair-like and fine at the tip; stout legs; first posterior cell slightly open or closed.

[1] Rosenau, "Preventive Medicine and Hygiene."

Members of this family are known as "blow-flies" or "flesh-flies."

Sarcophaga carnaria is a grayish fly with three stripes on thorax and black spots on each segment of abdomen. It is viviparous, the larvæ being deposited on decaying flesh. They may gain access to and develop in the nasal and other cavities. They are the most frequent larvæ found in cases of intestinal myiasis, and they are the maggots sometimes seen in neglected and improperly treated wounds of warfare.

Œstridæ. Bodies hairy, giving them a superficial resemblance to bees; mouth-parts almost vestigial; antennæ inserted in round pits, with terminal bristle on the third joint.

The Œstridæ are known as the bot, warble, or gadflies. The larva may become parasitic either in the nasal or pharyngeal cavities or under the skin or in the alimentary canal.

Rodentia. This order is characterized by the peculiar form and structure of the frontal incisor teeth, only the front of which are covered with enamel. This keeps them sharp and chisel-like, due to the more rapid wearing away of the softer dentine. They are especially adapted for gnawing and grow throughout the life of the animal.

Phylum: *Vertebrata*
- Class: *Mammalia*
  - Order: *Rodentia*
    - Family: *Muridæ*
      - Subfamily: *Murinæ*
        - Genus: *Mus*
          - Species: *Mus musculus*—The common house mouse.
            Mus rattus—The English black rat.
            Mus alexandrinus—The Egyptian or roof rat.
            Mus norvegicus—The brown or Norway rat.

The rodents are cosmopolitan, include by far the greater number of species, and have the widest distribution of any of the orders of terrestrial mammals. They are very abundant in South America.

Mus. The members of this genus have narrow, ungrooved incisors and three molars; soft fur mixed with hairs or sometimes with spines; a long, ringed, or scaled tail, sometimes nearly or quite naked; a rudimentary thumb or pollex armed with a short nail instead of a claw; large, outstanding ears, large, outstanding eyes, and a pointed muzzle.

The distinction between rats and mice is based on size, and is arbitrary. The black rat and the roof rat are regarded by some as races of the same species. The difference is largely one of color. The brown or Norway rat is also called the gray rat, sewer rat, wharf rat, and barn rat. It is the largest, most destructive, and most ferocious, and soon drives out the black rat. It is difficult to suppress it, as it protects itself by burrowing. The house mouse survives an invasion of brown rats, as it gets into holes too small for the rat to follow. Albinism, relinism, and pied forms are common in all species. The white laboratory animals are albino forms.

Life History of Rats. This knowledge is important to students of preventive medicine, as plague is primarily a disease of rodents, especially of rats.

The brown rat is the most prolific species. It breeds from three to five times a year with six to nine or sometimes as many as twenty young in a litter. They breed less rapidly in climates with extreme temperatures. Their multiplication is only limited by their nesting opportunities and food supply. Being primarily nocturnal animals, few are seen during the day, but they swarm at night wherever food may be found, especially in such places as markets, warehouses, stables, sewers, and along wharves and river fronts.

The rat, especially the brown rat, is migratory in its habits, and its movements are governed by the food supply. Seasonal migrations from houses and barns to green fields in the spring for plant food, and back to buildings for stored food in the fall are common occurrences. It is impossible to keep ships free from rats. They get on board vessels at their docks and are sometimes carried on board in the cargo. In this manner rats and their diseases have been carried all over the world.

Rats are practically omnivorous, and are also cannibalistic. They will eat seeds, grain, flour, green vegetables, bulbs, growing plants, eggs, chickens and other young animals, milk and milk products, fresh meat, shell-fish, crustaceans, and carrion. Their extensive menu enables them to survive under almost any conditions.

The black rat and the roof rat are more given to climbing than the brown rat. They live in walls or in the spaces between roofs and ceilings. The brown rat lives in burrows in the cellar and lower parts of buildings. All species climb trees to secure fruit, and in the tropics the black rat and roof rat nest in trees.

Their nocturnal habits are responsible for defective vision and uncertain movements by daylight, unless at the side of the room and in contact with the wall, when their movements are very rapid. The vibrissæ or whiskers probably serve as feelers. They make use of narrow places as runways.

Vegetable Parasites

General Considerations. The relationship between the lowest algæ and the lowest protozoa is so close that attempts to classify them absolutely have so far been fruitless. No one feature separates the lowest animals from the lowest plants; in many cases it is impossible to distinguish between them. The bacteria, the lowest organisms of all, are classed as plants, as they possess more or less rigid bodies, many grow in filaments, and most of them nourish themselves upon pure inorganic compounds. They resemble animals in that they are motile, none possess chlorophyl, and some require organic food.

Some of the properties of bacteria are fairly constant under uniform conditions, but their morphology is so subject to change under different conditions that it may be no index whatever to the relation of a given bacterium to disease or fermentation. Therefore in classifying microörganisms only genera are based upon morphological characteristics, while species are based upon biochemical, physiological, and pathogenic properties.

Properties of bacteria that have been utilized in systems of classification are spore formation, capsule and flagella formation (motility), reaction to staining agents, relation to temperature, oxygen, pabulum, fermentation, and disease. In many groups of organisms, any one of these properties would be unsatisfactory as a basis of classification, as under certain conditions they might so vary that it would be necessary to transfer an organism from one group to another. For example, the ability to produce capsules or flagella may be lost or held in abeyance, or its relationship to oxygen may be so changed that an anaerobic organism may multiply in the presence of oxygen, or vice versa.

Apparently certain of the bacteria retain some of their specific characteristics for an indefinite time. Since the beginning of our scientific study of bacteria most pathogenic species have remained practically unaltered. We still lack definite knowledge of the significance of such mutations as have been observed.

In view of the lack of a universally accepted classification of the vegetable pathogenic microörganisms the following, slightly modified from Park and Williams, is considered the most practicable:

Working Classification of Pathogenic Vegetable Micro-organisms

Kingdom: *Plants*
- Class: *Fungi*
  - Order: *Molds* (*Hyphomycetes*)
    - Family: *Mycomycetes*
      - Genera: *Aspergillus*, *Pencillium*
    - Family: *Phycomycetes*
      - Genus: *Mucor*
    - Family: *Unclassified* (*Fungi imperfecta*)
      - Genera: *Microspora*, *Trichophyta*, *Sporotricha*, *Achoria*
  - Order: *Yeasts* (*Blastomycetes*)
    - Family: *Oidia*
      - Genus: *Oidium*
    - Family: *Saccharomycetes*
      - Genus: *Saccharomyces*
  - Order: *Bacteria* (*Schizomycetes*)
    - Family: *Cocci* (*Coccaceæ*)
      - Genera: *Micrococcus*, *Diplococcus*, *Streptococcus*, *Tetracoccus*
    - Family: *Bacilli* (*Bacteriaceæ*)
      - Genus: *Bacillus* (*Bacterium*)
    - Family: *Spirilla* (*Spirillaceæ*)
      - Genus: *Spirillum*
    - Family: *Higher bacteria* (*Trichobacteria*)
      - Genera: *Cladothrix*, *Nocardia* (*Streptothrix*)

The Molds (*Hyphomycetes, Eumycetes*). This group embraces a miscellaneous collection of organisms closely related to the higher bacteria. They grow in branching filaments or threads, forming a mycelium, but these mycelia or hyphæ are more definite than those of the trichobacteria. In some varieties (*mycomycetes*) the filaments are always multicellular, in others (*phycomycetes*), only when forming spores. Some varieties are classified under the "Imperfect fungi." All are capable of producing fermentation or putrefaction.

The following genera are important: 1. Achorion. 2. Tricophyton and Microsporon. 3. Mucor. 4. Aspergillus and Eurotium. 5. Pencillium.

Yeasts (*Blastomycetes*). Yeast cells show wide fluctuations in size, even in the same species or the same culture. In old colonies individuals may be found no larger than cocci, while giant cells, 40 μ or more in diameter, are seen in other colonies or on the surface of a liquefied medium. The organisms are elliptic in form and surrounded by a sharply defined, doubly contoured, highly refracting, transparent cell membrane. They multiply by gemmation or budding, hence called blastomycetes. Spores possessing great vitality are formed.

The yeasts, especially *Saccharomyces cervisiæ,* are of great importance in brewing and baking. They are frequently present in the air and are not uncommonly found in cultures made from the throat. Certain varieties are capable of producing tumor-like growths when injected into the tissues, others are pathogenic for mice, and some cases of human infection have been reported. Blastomycetic dermatitis is caused by *Blastomyces dermatitidis.*

Bacteria (*Schizomycetes*).—*Definition.* Bacteria are exceedingly minute, simple unicellular microörganisms occurring singular and free or in larger or smaller masses or colonies, the individuals of which remain physiologically independent.

Natural Habitat. The different varieties are adapted to a wide range of conditions of life and nutrition. They are found throughout the world. One form or another will flourish wherever there is sufficient moisture between 0° and 75° C. Some species exist only in human tissues, others in lower animals, many in both men and animals, still others multiply only in vegetable tissues, but the greatest number thrive in decaying organic matter.

Size. A special unit, the micron, micromillimeter, or one twenty-five thousandth (1/25,000) of an inch, has been adopted for the measurement of bacteria. The dimensions of the individual cells vary greatly in the different species, as well as in members of the same species. There are bacilli 50 to 60 microns long and other organisms that can be seen only with the high power of the microscope. Some are ultramicroscopic, e.g., invisible with any power of the microscope.

Structure. Apparently bacteria possess both chromatin and plastin, the chief elements of a cell. Varying with the species and according to the stage of growth and division the chromatin may be in the form of morphological granules or may be mixed with the plastin and so finely divided as to be indistinguishable from it. Vague nuclear formations may sometimes be observed in bacterial cells after staining with nuclear stains. A very little cytoplasm exists between this formation and the cell wall. It is sometimes granular and sometimes contains granules of sulphur, fat, or pigment. The quantitative chemical composition of bacteria is dependent upon their nutriment, and is subject to wide variations. It is approximately 80 to 85 per cent water, the remaining dry portion being chiefly protein and fats. In some species the distinct cell wall which surrounds each bacterium gives the cellulose reaction with iodin, due to the presence of hemicellulose in the membrane. This membrane is well developed in some bacteria, as Bacillus tuberculosis. It is closely related to the living part of the cell and is possibly a concentrated part of the cytoplasm, resembling the ectoplasm of higher cells. The connection between the flagella and cell wall is close. A substance related to chitin is found in some species.

Certain bacteria, as Bacillus aerogenes capsulatus, at times appear surrounded by a halo or capsule, due to a peculiar gelatinous change in the cell wall or to an exudation of gelatinous material from the cytoplasm. These capsules develop best in animal tissues. When grown in cultures they generally require for their development special albuminous media such as blood serum or milk. On ordinary culture media the capsules may be indistinctly visible in the first generation grown from the body. Special staining methods are required to demonstrate them. This is of value in differentiating between closely related species.

Many bacteria, especially those of the diphtheria group, possess deeply staining bodies spoken of as metachromatic granules, polar granules, or bodies or Babes-Ernst granules. They stain distinctly dark in contrast to the rest of the bacterial cell with methylene blue. Their significance is unknown. They are seen most frequently in organisms taken directly from the lesions of disease or from young cultures.

Motility. Most of the spherical bacteria are devoid of appendages, but many of the rod and spiral forms, especially saphrophytes, are provided with fine, hair-like flagella. The presence of the latter generally implies motility, but they may also serve to stimulate the passage of nourishing fluid past the bacterium and so aid in its nutrition. Bacillus megatherium has a limited ameboid movement. Some of the spherical bacteria exhibit the Brownian movement, making it difficult to determine whether the movement is real motility or vibration. In the latter case the organism does not change its position relative to surrounding objects.

Growth and Reproduction. Bacteria multiply by fission or cell division. When about to divide they increase somewhat in size, and the spherical forms appear more or less ovoid.

The nuclear material probably divides first. The fission or cleavage may be in one, two, or three planes. Governed by the limitations of cleavage direction, the cocci assume a chained appearance (streptococci), a grape-like appearance (staphylococci), or a cubic or bale-like appearance (sarcinæ). The bacilli and the spirilla divide in the direction of the short axis. After division the individuals may separate from each other or may remain mutually coherent. The extent of the cohesion varies with the species and this, together with the plane of cleavage, is of assistance in determining the morphology of cell groups under observation. The rate of multiplication varies with the favorable or unfavorable character of the environment, and to some extent with the species. The average time required for the life-cycle of a bacterium is from twenty to thirty minutes. Under ideal conditions it is possible for a single germ to yield 1600 trillion descendants in one day. Such a rate of growth is rarely possible even under ideal artificial conditions, on account of lack of nutritive material and because bacteria in their growth soon produce an environment unfavorable to their further multiplication. Suitable food and moisture are exhausted; nutrient substances are disintegrated into acids, alkalies, ferments, and other injurious products; in mixed cultures one or more varieties overgrow the others.

Sporulation or spore formation is the power possessed by a large number of bacteria of developing into an encysted or resting stage, when the conditions for rapid development by fission are no longer favorable. The true spores or endospores are refractile and glistening bodies, round or oval in shape, and composed of concentrated protoplasm developed within the cell and enclosed in a dense envelope. They are most frequently formed in the bacilli and spirilla, but have been observed in cocci. These bodies are capable of resisting the influences of heat, cold, desiccation, and chemical action, within certain limits. They are stained with difficulty. Each organism produces, as a rule, one spore situated either at the center or at the end. When the germ is distorted by the contained spore it is known as a clostridium. A distending spore at the end forms a "Trommelschläger" or drumstick. These are frequently formed in anaërobic bacilli.

The formation of arthro spores is apparently the conversion of the entire organism into a permanent form or spore. They are abnormally large cells with increased staining properties and generally with thickened cell walls.

When spores germinate they absorb water, lose their shining, refractile appearance, and become swollen and pale. A protuberance develops at one end (polar germination), or at one side (central or equatorial germination). This grows into the new organism consisting of soft protoplasm enveloped in a membrane formed from the endosporidium, or inner layer of the cellular envelope of the spore. The exosporium, or outer envelop, may be absorbed, as often happens after equatorial germination, or may be shed and remain near the new-born germ.

Most of the spore-bearing pathogenic bacteria are anaërobes. The anthrax bacillus is the only pathogenic aërobe which forms endospores.

Morphology. The three principal forms of the single bacterial cells are spheres (cocci), rods (bacilli), and segments of spirals (spirilla).

Cocci. The average diameter of pathogenic cocci is about 0.8 micron. At maturity the cell is apparently spherical, but the process of multiplication causes alteration in the form, especially of the diplococci. The diplococcus of pneumonia becomes lance-shaped and gonococci appear to be flattened against one another.

Bacilli. This group is rod-shaped or cylindrical in form. The length of the fully developed cell is always greater than its breadth. The size of the bacilli varies greatly in the different varieties. The pathogens average 2×0.5 microns. They also present considerable variation in form; some have square ends, as Bacillus anthracis; some have rounded ends, as Bacillus subtilis; some are long and slender, others ellipsoid. Some only occur singly; others nearly always form threads or chains. Except when they develop spores or granules bacilli divide only in the plane perpendicular to their long axis.

Spirilla. These bacteria are spiral-shaped and resemble a corkscrew. They are twisted on the long axis, which lies in two planes. The spirilla divide only in one direction. One cell, or two or more cells clinging to one another may resemble a segment of a spiral or a comma-shaped form, an S-shaped form, or a complete spiral.

Variations of Form. Variations from the principal forms are not common among bacteria under normal conditions. Club shapes, formed by a thickening of the cell body at one or both ends, are not infrequently seen in the glanders bacillus and among the diphtheria group. An irregular beading is sometimes seen in Bacillus tuberculosis under normal conditions. These are not degeneration or involution forms as they are seen in actively growing, young cultures under normal conditions. The sizes and contours of bacteria may vary slightly according to the culture media in which they are grown, possibly due to osmotic relations. Some bacteria appear larger and less dense when grown in fluid media than they do when grown upon solid media.

Degeneration and Involution Forms. These occur when bacteria are grown under conditions not favorable to their development or when they are cultivated for a long period upon artificial media without transplantation. In old cultures of the diphtheria bacillus long, irregularly beaded forms with broad expansions at the ends may be found. In cultures of some of the spirilla degeneration forms may appear within two or three days after transplantation. Prolonged cultivation on artificial media or other unfavorable influences will produce variations in most organisms.

The Higher Forms of Bacteria. This is a group of organisms midway between bacteria and molds. They have filamentous forms with real or apparent branchings. The filaments are irregularly segmented and the free ends only seem to be endowed with reproductive functions. Among the lower forms segments of the filaments become separated and grow as unicellular forms. The growth of the higher forms shows some independence of their parts. One end may become attached to some fixed object while growth occurs from the other end.

1. Leptothrix. These grow in stiff, long, almost straight threads that do not branch. They are rarely pathogenic and grow sparingly on the usual culture media.

2. Cladothrix. These produce long, thread-like filaments that rapidly fragment and produce false branching, that is branches seem to originate from the filaments, but the connection between the thread and the branch is not distinct. The growth is Y-shaped, due to the terminal cell remaining partly attached but being pushed aside by further growth from the parent filament.

They are plentiful in the atmospheric dust, and frequently contaminate culture media, and are then known as bacterial "weeds." In old cultures they may resemble bacilli. There are no known pathogenic species.

3. Actinomyces. These develop thread-like forms with true branching. They are characterized by the clavate expansion of the ends of the radiating, wreath-like filaments. Spores have been observed. They are best seen in sections of diseased tissues containing the organisms, and are grown with difficulty in artificial media.

Actinomyces bovis and Actinomyces maduræ are pathogenic for man.

4. Streptothrix (*Nocardia*). These are thread-like organisms which produce abundant true branching with later fragmentation and the formation of endospores or conidia. There is a possibility that some varieties are pathogenic. It has been suggested that Bacillus tuberculosis is a form of streptothrix, as old cultures show branching involution forms.

The higher bacteria multiply by the production at the free ends or at intervals along the filaments, of small, rounded cells known as spores or conidia, from which new individuals are developed. After separation from the parent filament the terminal spores may be flagellated and resemble protozoan flagellates.

Biology of the Vegetable Parasites

Distribution. While bacteria and their spores are found in air, water, soil, and food, they are not ubiquitous, for their distribution depends upon the presence of nutritive matter, and favorable conditions of temperature and moisture. They are not found in the atmosphere at very high altitudes nor in glacial ice, but exist wherever living or dead organic matter is present. Most of the bacteria found in the air are harmless saphrophytes. Their presence in the soil depends upon the depth to which organic matter penetrates. Stagnant pools contain myriads of germs, while deep wells, if unpolluted, contain very few.

Nutrition. Diffusible albumins are the best food for bacteria. Most culture media for their artificial growth contain organic matter to supply carbon and nitrogen, water in abundance, and salts, usually those of calcium, magnesium, sodium, or potassium. Some varieties require the salts of sulphur, phosphorus, or iron. *Bacillus tuberculosis* will grow in a mixture containing ammonium carbonate, potassium phosphate, magnesium sulphate, and glycerine. Some micro-organisms will grow in water containing a minute amount of organic matter, while others require as concentrated an organic medium as blood serum. It is doubtful if any forms of bacteria can multiply for any length of time in pure distilled water. A species adapted to a special medium can sometimes become gradually accustomed to another, though immediate change would kill it. The addition of certain substances, such as glycerine or glucose, to a medium, will at times cause the growth of an organism that could not otherwise be cultivated upon that medium. Bacillus tuberculosis is so influenced by the addition of glycerine to agar-agar.

Strict parasites need a living host for their existence. *Strict saprophytes* live upon dead matter only, almost always organic. This group contains most of the bacteria. They are harmless to living organisms and are the cause of decomposition, putrefaction, and fermentation, and a special group produces nitrification. *Facultative saprophytes* can lead a saprophytic life, but thrive best in living tissues. *Facultative parasites* may grow within living tissues, but usually grow on dead material.

Yeasts are best cultivated upon media containing sugars, but will grow upon those containing diffusible protein and non-fermentable carbohydrates and glycerine.

Molds multiply most rapidly in media containing fermentable carbohydrates, but flourish upon most organic matter. Most of the true bacteria thrive best in a feebly alkaline or neutral medium, and their growth is inhibited by an excess of either acid or alkali, though this rule has some exceptions,—for example, Bacillus butyricus thrives in strong acid and Micrococcus urea in strongly alkaline media.

Temperature. The *optimum* is the temperature at which bacteria grow best; the *maximum* is the highest at which they can survive; and the *minimum* is the lowest at which they continue to multiply.

Bacteria usually multiply most rapidly at a comfortable room temperature, about 17° C. Slight variations do not affect them.

Most parasitic germs develop best at a temperature near that of their host. Many saprophytic germs grow best below 37° C. Microörganisms are more or less quickly killed by temperatures above that which allows their growth; a lower temperature than that favorable to the growth of an organism decreases its activity, but may not permanently injure it unless frozen for some time. When cultures are frozen the greater number of the organisms are killed, and subsequent development takes place from the few survivors.

A temperature of 75° C. kills most bacteria. Spores survive in boiling water for some minutes; they are killed by dry heat at 150° C. in an hour; 175° C. in five to ten minutes. A few species growing in manure heaps and hot springs, known as *thermophylic bacteria,* grow at such high temperatures as 60° to 70° C.

Moisture. A certain amount of water is essential to the growth of all bacteria. Culture media should contain at least 80 per cent of water. Nutritive materials must be in a state of solution in order to be absorbed by the bacteria, though some species will grow when the amount of moisture is exceedingly small, as upon crackers and bread. Development soon ceases upon dried culture media. When media are dried gradually at room temperature, some even non-spore-bearing bacteria live for a long time, but most of the organisms in a dried culture die in a few hours. Complete desiccation eventually destroys most of the pathogenic bacteria.

Spores are much more resistant than vegetative forms. In tissues or exudates bacteria resist drying longer than when unprotected.

Oxygen. Most microörganisms require free oxygen for their growth, though some fail to grow unless it is excluded, the latter class deriving it from its chemical combinations.

Aërobic organisms grow only in the presence of free oxygen, free admission of air being especially required for their spore formation. Bacillus tuberculosis and Bacillus diphtheria are strict aërobes.

Anaërobic organisms thrive and form their spores only when free oxygen is totally excluded. The tetanus bacillus, the bacillus of malignant edema, and many soil bacteria are strictly anaërobic.

Facultative or optional anaërobes are those that are capable of withstanding some restriction in the amount of oxygen without being seriously affected. This includes Bacillus typhosus and most of the pathogenic species.

When the amount of oxygen is unfavorable for a given variety of germ, the formation of spores, toxin, pigment, etc., is more or less restricted, but the production of the poisonous products of decomposition may be increased.

Light. Direct sunlight, and to a certain degree the rays of the electric arc light, retard and in some instances kill bacteria. Some of the sulphur bacteria utilize the sunlight in their metabolic processes in the same manner as the chlorophyl plants. Most non-spore-bearing bacteria, including Bacillus typhosus, Bacillus tuberculosis, and Spirillum choleræ asiaticæ, are experimentally killed by the direct rays of the sun in from two to ten minutes. Rays of certain colors, especially blue, are very detrimental to the growth of bacteria.

The presence or absence of ordinary diffused daylight does not influence the growth of most germs, though the virulence of many pathogenic species is gradually attenuated by continuous exposure to the light, while molds and yeasts thrive best in the dark.

Bacteria are not killed by the X-rays, though the vitality and virulence of cultures directly exposed to their action for prolonged periods seem to be slightly diminished.

Radio-active fluids have a slight inhibiting effect on bacterial growth.

Chemical Agents. Strong acids or strongly oxidizing substances may destroy the bacterial cells by rapid oxidation. Some chemicals, as $HgCl_2$, may coagulate the bacterial protoplasm; others, as formalin, may diffuse through the cell membrane and exert a toxic effect by chemical combination with the protoplasm. Chemical agents in solutions containing microörganisms may influence the activity or destroy the life of the latter by causing changes in the osmotic pressure.

Substances that inhibit the growth of bacteria are known as *antiseptics;* those that destroy the bacteria are spoken of as *germicides.*

Movement. Rest is apparently the condition best adapted for the growth of most species of bacteria. Violent agitation, as in a rapidly flowing river, may hinder or prevent their development. The fact that some species are more quickly autolyzed after violent shaking is utilized in the manufacture of bacterial vaccines.

Association of Different Species. Symbyosis is coöperative action in the equal and luxuriant growth of two or more species. For example, the streptococcus is more active when combined with Bacillus prodigiosus. *Antibiosis* is an antagonistic action in which one species prevails over others, as do the lactic acid bacteria in the intestines. In the natural state bacteria are usually found in mixed cultures.

Results of Microbial Energy. Bacterial processes cause many well-known and vitally necessary changes in nature. The chemical interchanges between the animal and vegetable kingdoms are due to their constant activity in reducing complex organic substances to simple compounds, and life on earth is thus made possible. The dead bodies of animals and plants, the excreta and secreta of animals, are, by fermentation and putrefaction, reduced to simpler compounds and forms and absorbed as food by the green or chlorophyl plants.

Foods are altered in quality and either ruined or improved by the action of bacteria and other microörganisms. Some of these chemical changes are of a poisonous nature; others cause acidity, acridity, and insipidity, while the flavor of cheese, butter, and sausage and the aroma of wines are improved by microbial activity.

The action of bacteria upon organic matter is utilized in the "septic tank" system of sewage treatment, which leaves the sewage water clear after the bacteria have consumed the contained organic matter.

The principal results of microbial energy are as follows: Fermentation, putrefaction, chromogenesis, production of gases, production of acids and alkalis, production of phosphorescence, production of aromatics, production of odors, liquefaction of gelatin, peptonization of milk, formation and reduction of nitrates, combination of nitrogen, production of enzymes, pathogenesis.

Fermentation. Fermentation is the chemical decomposition of carbon compounds caused by the biological activities of living organisms (organized ferments or enzymes) or by chemical substances thrown off by the organisms (unorganized ferments or enzymes), the alcoholic fermentation caused by yeast being the most familiar example. Sugar is broken up into alcohol and carbon dioxide with glycerine and other by-products. Bacillus aceticus and several other bacteria produce the acetic fermentation; Bacillus acidi lactici and Bacillus butyricus, with some other species, cause respectively the lactic-acid and butyric-acid fermentations.

Putrefaction. Putrefaction is the decomposition or cleavage of proteins as the result of the action of microbial ferments or enzymes. They are generally first peptonized and then further decomposed into gases, amino-acids, bases, and salts, in which process disagreeable odors are evolved.

The products of putrefaction are: peptone, ammonia, and amines; leucin, tyrosin, and other amino substances; oxy-fatty acids, indol, skatol, phenol, mercaptans, carbonic acid, hydrogen, sulphureted hydrogen, marsh gas, ptomaines and toxins.

Chromogenesis. Pigment production is of interest chiefly in identifying bacteria. The pigment-forming or *chromogenic* bacteria are mostly saprophytes and non-pathogenic. Some pathogens, as Staphylococcus pyogenes aureus and Bacillus pyocyaneus, are chromogenic.

There are two kinds of pigment, one, being soluble, saturates the culture medium, as the pyocyanin and fluorescin of Bacillus pyocyaneus; the other, insoluble, is retained in the colonies like the pigment of Bacillus prodigiosus. Except in Bacillus prodigiosus pigment, granules are not seen in the cytoplasm of the bacteria; it is entirely intercellular.

Most of the colors are produced by bacteria, some species producing more than one, as Bacillus pyocyaneus, forming blue pyocyanin and green fluorescin.

The presence of oxygen seems to be necessary for the formation of most pigments.

Production of Gases. As stated above, a number of gases are evolved during fermentation and putrefaction. Ordinarily the gases formed by aërobic bacteria escape unobserved from the surface of the culture medium. Those formed by anaërobic bacteria, especially the bacilli of tetanus and malignant edema, can be seen as bubbles around the colonies.

Some of the acid-producing bacteria develop gas in abundance, chiefly CO_2 mixed with hydrogen.

Production of Acids and Alkalis. In addition to acetic, lactic, and butyric acids formed during fermentation, formic, propionic, baldrianic, palmitic, and margaric acids are produced by microbial activity—this activity being impeded and finally inhibited by the increasing acidity.

Ammonium is the alkali most commonly produced by bacterial metabolism, being freed from its combinations and either escaping as a gas or forming new combinations with the acids which are simultaneously formed. When in excess, alkalis check the further activity of the organisms.

Acids only are formed by some bacteria; some produce only alkalis; others both acids and alkalis.

Production of Phosphorescence. Photogenesis. Microörganisms, called photogens, that produce phosphorescence, are quite widely distributed in nature, particularly in decaying meat and in saline media, as sea water. The emission of light is not usually due to the oxidation of photogenic substances given off by the organisms, but is a property of the living protoplasm. Only living organisms emit light, but photogens can live without producing light.

Production of Aromatics. Indol, skatol, phenol, kresol, tyrosin, and hydrochinone are common products of microbial growth; of these indol is the most important.

Production of Odors. In addition to the gases and acids produced by bacteria, there are a number of pungent odors which apparently are generated by independent odoriferous principles, an example being the onion-like smell of the tetanus bacillus.

Liquefaction of Gelatin. This apparently independent peculiarity of certain organisms is possessed by pathogenic and non-pathogenic species, and is due to a proteolytic ferment, gelase, resident in the excreted products of the bacteria, and not in the bacterial cells. The gelatin becomes partly or entirely liquefied, and its appearance, when acted upon by some bacteria, is so peculiar and characteristic that it forms a guide for the determination of species.

Peptonization of Milk. The power to digest or peptonize milk is possessed by many bacteria, and is due to the presence of rennin-like ferments, varying with different species. Some produce coagulation and some gelatinization; others digest the casein without apparent change, while still others digest the casein so completely that the milk is changed to a watery liquid. This quality of bacteria is utilized in the differentiation of species.

Formation and Reduction of Nitrates. As a result of putrefaction the nitrogen liberated in the decay of organic material reappears as ammonia, which is oxidized into nitrites and nitrates well adapted for plant food by certain species of soil bacteria. Some bacteria are able to reduce nitrogen compounds in the soil or in culture media into ammonia.

Combination of Nitrogen. The main supply of nitrogen available for plant life is in the atmosphere, where it cannot be utilized as a raw product by plants. The bacteria found in the root bulbs of leguminous plants aid in the assimilation of atmospheric nitrogen and in its preparation for further use by the plants.

Production of Enzymes. The enzymes or ferments produced by bacteria may be grouped as sugar-splitting, inverting, fat-splitting, proteolytic, diastatic, rennin-like or lab enzymes, and oxydizing enzymes.

Filterable Viruses

This name is given to a class of organisms either ultramicroscopic or with refraction and staining powers so faint that they cannot be demonstrated by our present methods. Their existence is known through the biological qualities of filtrates in which they are present by reason of their ability to pass through the pores of filters. Being invisible, there is no way of classifying them; they may be bacteria or protozoa, or neither or both.

The filtrates contain the virus and are capable of reproducing the disease with all its characteristics when inoculated into a susceptible animal. Examination under the highest power of the microscope shows the filtrate to be limpid and, except in a few diseases, to contain no characteristic particulate matter.

The symptoms caused by pathogenic filtrates must be shown to be due to microörganisms and not to toxins. This is decided by the successive inoculation of a series of animals with the filtrate from one previously so inoculated. (Park and Williams.)

The following named diseases are or have been stated to be caused by filterable viruses: Yellow fever, dengue, poliomyelitis, measles, scarlet fever, smallpox and vaccinia, rabies, trachoma, molluscum contagiosum, verruca vulgaris, fowl diphtheria, fowl pest, Rous' chicken sarcoma, foot and mouth disease, pleuro-pneumonia of cattle, African horse sickness, sheep-pox, cattle plague, hog cholera, swamp fever of horses, agalactia of sheep and goats, "blue tongue" of sheep, Guinea pig epizoötic, Guinea pig paralysis, Novy's rat disease.

Chapter II

INFECTION AND IMMUNITY

Infection is a successful attack upon the living body by microscopic or ultramicroscopic animal or vegetable organisms. It may be *endogenous* when the assault is by germs that habitually live on the skin or in the respiratory or alimentary passages, the genito-urinary tract, etc. This may be likened to an insurrection of resident aliens in a friendly country. Pneumonia is an example of this class of infections. *Exogenous* infection is caused by organisms that occasionally reach the body, resembling an invasion by a hostile army from across the frontier, exemplified by infection with cholera. Most of the organisms causing endogenous infection are, under ordinary circumstances, harmless parasites, but at times they cause infection through increase in their virulence or diminution in the resistance of the body.

A host is said to be *infected* by protozoal and bacterial parasites, but *infested* by metazoal parasites. The modes of operation and the disturbances produced by animal parasites, especially metazoa, differ from those of vegetable parasites or bacteria. The former vary according to the field of operations, the character of the invader, its life cycle, and mode of feeding. The tæniidæ cause emaciation and nervous symptoms; the strongylidæ, especially the hookworms through their blood-sucking proclivities, give rise to anemia; cysticerci lodged in the organs of special sense and the central nervous system produce functional derangements; suppuration and ulceration are the result of the presence of the guinea worm in the subcutaneous tissues; Filaria sanguinis hominis in the lymphatic system causes edema and infiltration of the tissues.

The damage to the body caused by bacterial invasion may be due to the mechanical action of the bacteria, their biological activities, the action of their chemical products, or any two or all of the foregoing. Mechanically they give rise to irritation, stasis, etc. Biologically their multiplication may cause local inflammation and abscesses, followed by infection of the whole body by metastasis *via* the blood and lymphatic systems. The chemical products of parasites, the toxins, etc., do the greatest harm.

The most common and important parasites are the bacteria, as they, like the poor, are always with us.

Portals of Entry. Bacteria gain admission to the body through the following named portals: Skin, eye, nose, mouth, lungs, stomach, intestines.

Skin. As the protective action of the skin is mechanical, bacteria do not penetrate the normal, unbroken integument. The germs of suppuration, especially if incorporated in an unguent such as lanoline, may be rubbed into the skin and cause boils and abscesses, as has been proved by laboratory animals having been infected in this manner with anthrax, glanders, plague, and tuberculosis.

Infection through the skin occurs by the following modes:

1. Through wounds—suppuration, tetanus, syphilis.
2. The bites of insects—malaria and yellow fever by mosquitoes, plague by fleas, and typhus by lice.
3. The bites of animals—rabies from the bites of rabid dogs, wolves, etc.

Eye. Local infection of the conjunctiva by gonococci, causing gonorrheal ophthalmia, and by the germs of pus, resulting in simple conjunctivitis, is common. The seat of primary infection of syphilis, tuberculosis, anthrax, and diphtheria is occasionally the conjunctiva. Animals have been experimentally inoculated through the eye with plague, glanders, and rabies.

Nose. The nasal secretion has marked germicidal qualities, but nevertheless infection occurs through this channel. It may be the seat of primary infection with glanders and possibly leprosy and poliomyelitis. Rats may be easily infected through the nose with plague.

Mouth. The epithelium of the mouth is a good mechanical protection, and the normal saliva has bactericidal action, but the germs of pneumonia, diphtheria, tuberculosis, syphilis, and actinomycosis are uninfluenced by the latter.

Considering the filthy condition of many mouths, the wonder is that more infections do not occur through this route. Tartar is very deleterious to the gum; food between the teeth is a medium for the growth of bacteria; carious teeth are avenues of entry for bacteria into the system.

Micro-organisms lodge and grow in the crypts of the tonsils, and some of these find their way into the lymph and blood, from which they are deposited in the lungs and other organs. Possibly some cases of pulmonary tuberculosis are infected in this manner.

Many pathogens pass through the nose and mouth, causing no local infection, but multiplying later in the lungs or intestines.

Due to the filthy habits of many supposedly cleanly human beings, the circuit of fecal-borne infections from their own or other people's intestines to their own mouths *vià* the dirty hands' route is frequently short and at times disastrous.

Lungs. The evidence now at hand seems to show that in the majority of cases pulmonary tuberculosis is the result of inhalation, and that the primary seat of infection is in the lungs. It is also certain that pulmonary infection occurs by way of the intestinal tract, animals having been experimentally infected by both methods.

Stomach. The HCl of the gastric juice affords much protection to its own walls from infection through food, and some against intestinal infection, but all kinds of bacteria get by this guard, especially during intervals of digestion. Gastric digestion does not completely sterilize the food.

Pus germs cause gastric ulcer, but duodenal ulcer is more frequent, as the alkaline medium of the intestine is more favorable to their growth than the acid medium of the stomach.

There is probably no specific stomach disease that develops primarily from stomach infection. (Vaughn.)

Intestine. The intestine is the most vulnerable point for bacterial invasion, and the intestine of the infant is less resistant than that of the adult, not only to bacteria, but to the effects of all organic and inorganic substances. Tubercle bacilli may pass through the intestinal wall, leaving no lesion, but causing infection in other organs or tissues, though it has not been proven that this is the usual method. Von Behring states that the majority of cases of tuberculosis are due to milk infection during infancy, and that the bacilli are retained in the lymph glands and other organs, especially the lungs, and develop in later life.

Virulent cholera spirilla that would readily cause infection through the intestine are harmless if given subcutaneously.

It is difficult to say when the intestinal walls are in a state of normal health, and whether bacteria can readily traverse them when in that condition. Probably this does occur.

Infection by cholera, dysentery, and typhoid fever is exclusively through the intestine.

The invasion of bacteria generally occurs through the most appropriate avenue of entry, even though it is possible through several channels. This constitutes a typical infection by the given parasite.

After the pathogenic organisms gain admission to the body infection can only occur when certain conditions are fulfilled:

The germs must be virulent; they must be in sufficient number, and the host must be susceptible to their action.

To be virulent a pathogen must be able to break through or endure the attacks of the defenders of the body, e. g., the phagocytes, bacteriolysins, etc. A few germs might be overcome and destroyed, while the assault of a larger number would result in infection. What would be a lethal dose for one subject might be multiplied several times and be harmless to another. One anthrax bacillus might kill a mouse. The more virulent an organism the fewer will be the number required to infect. The ability of any invading parasite successfully to contend with the defensive forces of the body determines its pathogenic or disease-producing power. When the defense is successful the body is *immune*. When the assault is successful and the defenders are overcome, infection takes place, and the body is said to be *susceptible*.

Various factors control the results of infection:

1. The characteristics of the invader.
2. The mode of invasion.
3. The tissues invaded.
4. The metabolic products of the biological activity of the parasite.
5. The condition of the host, whether susceptible or immune.

The Characteristics of the Invader. A certain bacterium may be pathogenic to one species of animal and harmless to another. Some bacteria multiply more rapidly in symbiosis, others in pure culture. The anaerobes require the exclusion of oxygen, as in punctured wounds, for their growth.

The Mode of Invasion. Some bacteria, as anthrax, have great power of invasion, but limited toxic properties, intoxication being an important feature of infection only after invasion of the tissues has become general; others have limited invading power, but generate very active soluble toxins that act upon the body cells remote from the scene of activity of the bacteria themselves. Such are the bacilli of diphtheria and tetanus. Still others, with more active toxic properties, have but limited invading powers. A few of these, growing with difficulty in some relatively trivial focus, excite actively destructive reactions in the tissues with which they come in contact. Infection with the bacillus of chancroid is an example of this mode of invasion.

The Tissues Invaded. Some bacteria grow in certain tissues and not in others. The blood has little or no bactericidal action on tubercle or plague bacilli or streptococci. The cholera spirillum grows luxuriously in the intestine, but is quickly destroyed when injected subcutaneously. The bactericidal action of the blood may be great enough to kill even some pathogens injected directly into it, while the same dose given subcutaneously would cause infection. Diseased and injured tissues offer less resistance to infection than normal tissue.

The Metabolic Products of the Biological Activity of the Parasite. The dangerous or innocuous character of microorganisms depends largely upon the nature of their products; from the standpoint of medicine their most important products are toxins and toxalbumins, their disease-producing power being chiefly due to these substances. Enzymes are also important products of bacterial life, but their rôle in disease is apparently a minor one, though later research may increase their importance. Both fermentation and putrefaction are probably caused by enzymes, in the latter process putrefactive alkaloids known as ptomaines being formed. These are developed almost exclusively outside the living body and are dangerous only when ingested with food. Probably the diphtheria bacillus and the pneumococcus secrete a fibrin ferment or enzyme which precipitates the fibrin from the inflammatory exudates. Bacteriolytic enzymes are also formed that dissolve the bacteria themselves or digest them after their death.

Toxins and toxalbumins are evolved within the bacteria by metabolic processes and secreted in the surrounding media, whether albuminous or non-albuminous, ptomaines resulting from changes in the media.

Toxins are described as intracellular and extracellular. The former are insoluble and difficult to isolate, and their radius of action is confined to the area of distribution of the specific bacteria, the intensity of the reaction produced depending upon the activity and extent of the invasion, whether local or general; they are liberated only upon the dissolution of the bacterial cells. The extracellular toxins, such as those of the diphtheria bacillus and the tetanus bacillus, are apparently excretions of the bacteria, and are eliminated from them as soon as formed. They are soluble and readily diffuse throughout the culture media.

Toxins are unstable, proteid substances, but do not give the ordinary proteid reactions, changing into toxoids when exposed to light, heat, or oxygen, and are destroyed by a temperature of 60° C. in a few minutes.

The toxalbumins are less stable than the toxins. More knowledge of them has been derived from their clinical effects than from laboratory studies. They are present only in cultures of the specific organism in minute quantities. The viruses of typhoid fever and cholera are apparently toxalbumins.

The culture filtrates of bacteria are very complex, and contain—in addition to the metabolic products of the bacteria—toxins, toxalbumins, enzymes, lysins, pigments, acids, etc.—substances formed as the result of changes in the medium produced by the abstraction of molecular constituents utilized as food by the bacteria. This makes it very difficult to study accurately the toxins and differentiate them from their associated products. Slight variations in the composition and reaction of the media in which the bacteria are grown cause experimental results to differ. No doubt like variations occur in living animals, which demonstrates the extreme difficulty of foretelling the effect of pathogenic bacteria on different animals.

The action of extracellular toxins differs materially from that of intracellular toxins, being more readily diffused through the body juices, and their diffusion not being dependent on the powers of invasion of the bacteria. The bacillus of tetanus may multiply very slightly in an obscure or undiscovered focus, and yet its toxins cause the death of the animal by action on the central nervous system.

Bacteria producing similar types of viruses cause the same general effects in animals. Suppuration and elevated temperature follow infection by many different species—results which are non-specific. When a clearly defined effect is the result of infection by some one species it is said to be specific, tuberculosis and leprosy being examples. If the specific effect is constant enough to be clinically classified it constitutes a disease, as cholera.

Condition of the Host—whether Susceptible or Immune. *Susceptibility* is liability to infection. (McFarland.) A high degree of susceptibility is known as *predisposition* or *dyscrasia*. An animal may from time to time vary from marked predisposition to immunity to a given infection, the ability of the animal to defend itself successfully against the invasion of pathogenic bacteria being diminished by depression of its general physiological activity. These changes are only partially understood, and are very difficult to observe and study. Individuals of the same species differ widely in susceptibility. If many thousands of people drink water from the same specifically infected water supply, a few thousands may be attacked with cholera severely enough for the cases to be recognized clinically, other thousands may have mild attacks unrecognized clinically, and still others escape with no symptoms whatever, though some of the latter may succumb to later and possibly larger doses of the disease germs. Susceptibility is influenced by a number of factors, including age, race, temperature, loss of sleep, mental disturbances, overcrowding, abuse of alcohol, etc. A man may carry virulent pneumococci in his respiratory tract for years and be unaffected, but succumb when his defensive forces are weakened by an alcoholic debauch. A happily married woman may live in good health for years, but when depressed by the worry and anxiety of poverty and widowhood fall an easy victim to tuberculosis.

Immunity is the ability of the living body successfully to antagonize the invasion of parasites or to neutralize the injurious qualities of their biological products—a fundamental function of all living things, animal and vegetable. Without its possession, at least in some degree, life would be impossible, as all living things are constantly exposed to the attacks of parasitic enemies. Animals ordinarily resist the infective power of constant tenants of the body, such as the colon bacillus and the hay bacillus, that successfully invade the body at death or shortly before.

Immunity expresses the opposite condition to susceptibility. Tolerance is the term used to express the limited form of immunity acquired by the continued use of alcohol, alkaloids, and other poisons of relatively simple chemical structure, and differs from true immunity in that antibodies are not formed in the blood.

Immunity is a relative term, and varies greatly in degree and duration. An animal might endure without injury as much toxin as could be produced in its own body, but succumb to a large dose produced in a test tube and injected into it. Natural immunity is the inherent, inherited power to resist infection peculiar to and possessed by all the animals of a given species—as the immunity of man to rinderpest and birds to anthrax. On entering the body of an animal immune to it a parasite is confronted by conditions inimical to its existence and multiplication, and therefore succumbs to the prowess of the defending forces.

Natural immunity is not always absolute. An animal's immunity may be destroyed by cold, starvation, change of diet, etc. In a very general way the infectious power of a given parasite is confined to certain species of animals more or less related to one another, anthrax, for instance, being most frequent among the herbivora, though some carnivora are susceptible, as are some of the cold-blooded animals. There are many exceptions to this generalization, even among closely related species. The apparent differences of immunity among races of the human species, as for instance the Ethiopian to yellow fever and the Mongolian to scarlet fever, are not entirely borne out by close research. Immunity to one kind of infection confers no protection against any other kind of infection or intoxication.

Acquired immunity is resistance against infection possessed by individual animals, and is not inherent in all members of the species. It is acquired during the lifetime of the individual, depending upon the introduction into its body of the specific pathogenic organisms or their products; it is more variable in its duration than natural immunity, is less certain, and is not transmitted to the offspring, though it may be acquired through the mother's milk.

Acquired immunity may be *active or passive;* natural immunity is always *active*. Active immunity is the result of an attack of the disease or one of allied nature, or is caused artificially by the introduction of a specific toxin or virus into the system, consisting of bacteria that have been killed by heat or diminished in virulence. In but few diseases will an attack confer lasting immunity, second and third attacks sometimes occurring, though their severity is, as a rule, much diminished—as, for example, smallpox and measles. Some diseases, as pneumonia and diphtheria, confer a temporary immunity, but subsequent attacks may be of equal or greater severity, while in other diseases, as malaria, immunity is acquired very slowly, and increased susceptibility may appear to have been induced. In active immunity the defensive mechanism of the body has been stimulated to aggressive action. Passive immunity is an antitoxic immunity. The antibodies (antitoxin) are introduced into the body and are not generated by the body cells. The formation of the antitoxin in the horse's serum by the introduction of diphtheria toxin causes an active immunity in the horse. The injection of this antitoxin into a human being causes a passive immunity in the latter. Both are acquired, as neither has a natural immunity to diphtheria. The use of bacterial vaccines in typhoid prophylaxis and the prevention of smallpox by vaccination with the virus are examples of active immunity.

By combining antitoxin and the corresponding bacterial virus both varieties of immunities may be utilized, the antitoxin diminishing in a measure the severity of the reaction which results from the use of the virus, affording some immediate protection, and covering the negative phase which is presumed to follow active immunization—a method which has been practically applied in plague prophylaxis.

Most of the reactions between the antibodies—lysins, precipitins, agglutinins, opsonins, etc., and the corresponding antigens are specific, but only relatively so, there being no absolute specificity.

Many parasites and their toxins exert their specific action by preference on certain cells and tissues. Thus the toxin of tetanus and the viruses of infantile paralysis and rabies select certain cells of the central nervous system for attack; the cholera spirillum, to be toxic, must find its way to the intestinal tract; in smallpox the virus has a predilection for the epithelial structures, skin, and mucous membranes. This specific action throws some light on the local immunity shown by some tissues, and the preference displayed by some parasites for their chosen portals of entry. Some germs, as those of tuberculosis and pus, will attack almost any organ or tissue in the body, though of course some tissues are more susceptible than others.

The specific action of toxins explains the immunity of certain species of animals to certain parasites. It is a negative quality, and not the result of any specific reaction or of any positive characteristic of the tissues. Specific chemical affinity simply does not exist between the toxin and the cells of the body.

General immunity is largely dependent on local resistance, and both depend upon the variation in susceptibility of the different tissues to various infections. Vascular structures offer better resistance to infection than those poorly supplied with blood. Wounds of mucous membranes readily heal, while parts deprived of their blood supply by trauma are readily infected. The greater the local reaction to the entrance of a parasite the greater is the chance of successful resistance to the invader. Organisms such as streptococci and plague bacilli, to which little or no local resistance is offered, cause rapidly fatal septicemias.

Practically nothing is known of the *actual* physical and chemical processes by which animals develop a defensive mechanism against a given virus, an analysis of the protoplasm being an impossibility, because of its exceedingly complex chemical structure. The products which result from the action upon it and the combination with it of various nutritive materials and toxins are equally complex, the nutritive materials promoting metabolism, the toxins disturbing it. Immunology deals largely with toxins which under some conditions disturb or destroy the protoplasm and under others are met and successfully antagonized by the products of the metabolic activity of the protoplasm, whereby disease is prevented and recovery promoted. We can only theorize as to the various chemical and physical reactions and changes that occur in a living body during immunization. Two theories of immunity are now seriously considered: the cellular theory of Metchnikoff, or theory of phagocytosis, and the humoral theory of Ehrlich, or the side-chain theory.

Before proceeding to elaborate these theories it is well to define certain terms and describe certain factors used and concerned in the study of immunology.

The Theory of Phagocytosis. Phagocytosis is a function of all cells having ameboid motion, and is the only means possessed by the lowest forms of animal life whereby organic food may be secured. It is retained by certain cells, the phagocytes, in the higher animals. Phagocytes ingest matter of all kinds, organic and inorganic; they are more than scavengers, as they engulf and digest live as well as dead bacteria—particles of coal and dust of various kinds, malarial and blood pigment, necrotic tissue, silk and catgut ligatures being disposed of in this manner. Many biological changes are the result of phagocytosis. Such are the metamorphosis of animals, including the loss of its tail by the tadpole and the involution of the uterus after pregnancy. Probably under normal conditions phagocytosis is a dormant quality of mesoblastic protoplasm, but it is like an efficient regular army, instantly ready to answer war's alarms and attack invaders.

Metchnikoff grouped the phagocytes into the free and the fixed, the microphages and the macrophages. The free phagocytes comprise the leukocytes, lymphocytes, and the myelocytes derived from the blood marrow and other blood cells; the fixed phagocytes are the endothelial and connective tissue cells—the former being considered of the greater importance. The microphages embrace the polymorphonuclear and polynuclear leukocytes and the wandering connective tissue cells—the mast cells and eosinophiles possibly play a minor part. The macrophages are the mononuclear leukocytes, the endothelial cells of the peritoneum, the sessile (fixed) mononuclear cells of the splenic follicles and sinuses of the lymph glands, the stellate (Kupffer) cells of the liver, the large mononuclear alveolar cells of the lungs, the bone corpuscles, and the myeloplaxes or giant cells of the bone marrow. These classifications are quite arbitrary, as all the leukocytes are phagocytic in varying degrees.

Broadly speaking, the energies of the microphages are directed primarily against bacteria and those of the macrophages against protozoa. The microphages are the scouts of the defending army, the first to get in touch with the enemy, their activity being seen in all acute infections. The macrophages are the field and siege artillery, and are used in attempts to dislodge such entrenched chronic infections as tuberculosis and leprosy.

After ingestion by phagocytes living foreign cells are usually killed, though in some cases the bacteria may destroy the phagocytes. This is the case in the phagocytosis of tubercle bacilli by giant cells, and suggests the possibility of danger to the animal through the transportation of the parasites to other organs and tissues. Intracellular granular degeneration of bacteria may be observed under the microscope, and indicates the destruction of the bacteria by the phagocytes. Probably this is accomplished by the digestive power of the engulfing cells, which is analogous to gastric digestion, e. g., a proteolytic endolysin acting in an acid medium.

Phagocytic action must not be confused with the germicidal action of the leukocytes, which is dependent on soluble substances separated from the cells, and does not take place in the leukocytes themselves.

The digestive ferments of the phagocytes are called *cytases;* microcytase occurs in the microcytes or microphages, and macrocytase in the macrocytes or macrophages. The former are thermolabile and synonymous with alexin (Buchner) and complement (Ehrlich) ; the latter are thermostable and a factor in specific acquired immunity. As the macrophages fix themselves to the bacteria this substance is called by Metchnikoff the *fixator,* corresponding to the "substance sensibilisatrice" (Bordet) and the "amboceptor" (Ehrlich).

It is apparent from the foregoing that the mechanism of immunity is a much more complicated process than the simple physical act of the engulfment of parasites by phagocytes.

While spontaneous phagocytosis does occur, e.g., the engulfment of certain bacteria in the absence of blood serum, most pathogenic organisms become markedly subject to phagocytosis after exposure to the action of fresh serum. It was observed that the process was greatly facilitated if it took place in contact with or in the presence of the serum of an animal that had been immunized against the corresponding bacterium. Metchnikoff suggested the presence in the serum of substances, *stimulins*, that stimulated the leukocytes to greater activity. Others suggested that the effect of the serum was exercised on the bacteria, the endo- and exo-toxins of the organisms being neutralized, the latter thus being deprived of their strongest defensive weapons. These substances occur in both normal and immune serum and are called *opsonins* (*opsonare*, to cater to). If organisms are suspended for a while in fresh serum, then washed with normal salt solution, and subsequently exposed to the action of leukocytes, phagocytosis promptly occurs. If the leukocytes are first exposed to serum and subsequently washed, the results are negative. This experiment demonstrates the presence of opsonins in normal serum.

There is a difference of opinion as to the identity of the opsonins of normal and immune serum. Those who deny their identity call the opsonins of immune serum *bacteriotropins*, which are relatively thermostabile, while the opsonins of normal serum are instabile when exposed to a temperature of 56° C. for thirty minutes. The fact that normal opsonins are non-specific is a strong argument in favor of the existence of the two kinds of bodies, normal opsonins and bacteriolysins.

Phagocytic activity depends upon the joint action of two substances—the opsonic complement, a thermolabile constituent, and the opsonic amboceptor which unites the opsonic complement and the bacterium. The bacteriotropins of immune serum cannot act independently of the opsonic complement. Normal and immune sera act differently in phagocytosis when virulent and non-virulent strains of bacteria are studied. Non-virulent strains of streptococci are destroyed in the presence of normal serum, while virulent strains succumb only in the presence of immune serum.

There are marked differences in the degree of susceptibility to opsonic influence. The following organisms are subject to opsonification: *Staphylococcus aureus* and *albus, Micrococcus melitensis, Diplococcus pneumoniæ, Bacillus coli, Bacillus dysenteriæ, Bacillus anthracis, Bacillus typhosus, Spirilla choleræ, Bacillus tuberculosis.*

Of the physical and chemical changes that take place in bacteria as the result of opsonification little is definitely known; we are only certain that the process itself does not impair the vitality of the organisms.

While the demonstration of opsonins and tropins enlightened us as to the mode of action of leukocytosis and of the importance of the latter therein, the actual force, chemical or physical, whereby leukocytes are attracted toward certain bacteria and other organisms is still obscure. This unknown influence which causes the mobilization of defending leukocytes and their march to the points attacked by the invading bacteria is called *chemotaxis,* and denotes a certain sensibility of living protoplasm to various chemical substances—the leukocytes doubtless inheriting this from their protozoan forebears. The influence may be of a positive or negative nature—*positive and negative chemotaxis.* In bacterial infections negative chemotaxis may result from the invasion of a virulent strain of the same bacterium in which positive chemotaxis would be induced by a non-virulent strain. The defenders are forced to retreat by the fire of the picked troops of the invaders. In an infection in which the body relies mainly on phagocytosis for defense, the latter cannot occur in the face of negative chemotaxis—the phagocytes cannot destroy invaders that they cannot reach. The invasion is successful and a generalized infection is the result.

Relatively little is known of the nature of the substances which induce chemotaxis. Living bacteria are not essential, as the same results are attained by dead bacteria and their soluble products. The bacterial proteins may be the active agents that call forth the chemotactic influences. In negative chemotaxis the relative virulence of the organism plays an important rôle.

It is apparent from the above that leukocytes act as defensive forces only in the presence of opsonins and tropins, and when the virulence of the invaders is not too great. Agencies that lower the normal content of opsonins or prevent the ready formation of tropins would have the same result as increase of virulence in the invading bacteria. This explains the mode of action of the predisposing conditions of disease. Alcohol decreases opsonins, hence drunkards are very susceptible to pneumonia, as in this infection phagocytosis plays an important part in the defense. The pneumococci, normal tenants of the respiratory tract, take advantage of the weakened state of the defenses of the foreign country they are residing in as aliens and rise in insurrection.

Wright maintains that primary infection occurs as a result of lowered opsonic content of the blood. Others entertain the view that the opsonic content lowers because of the infection.

We now comprehend why hyperemia at the seat of invasion is useful in contending with bacterial infections—it may be the unaided effort of the body or be produced artificially by Bier's method, or by counter-irritation, physical or chemical.

In heavy infections the normal opsonins are almost immediately expended, as are the munitions of a poorly prepared country. The munition plants must immediately begin the manufacture of more opsonins and likewise new and special kinds of munitions—tropins—to match the armament and defenses of the invaders. We can only speculate as to the location of hypothetical ammunition factories. Simon suggests that the leukocytes themselves may generate the opsonins. It is apparently clear that the opsonins and tropins are produced by the body as a result of the absorption of bacterial products. The injection of vaccines (killed cultures) of bacteria will raise the opsonic content if used in proper quantities, an excess of vaccine causing a decrease of opsonins. The opsonic content of the blood fluctuates during the course of chronic bacterial infections with low opsonic content, such as tuberculosis, furunculosis, acne, and gonorrheal arthritis, which fact is due to the irregular absorption of bacterial products. Attempts are now made to raise the opsonic content by vaccine treatment, thus aiding the opsonic forces, in which endeavor other factors, such as the virulence of the bacteria, capsule formation, etc., must be considered. Phagocytosis may be absent, due to these factors, and account for the failure of attempted curative treatment by vaccination.

Before describing the humoral or side-chain theory of immunity, it is well to discuss briefly the various defensive agencies of the fluids and tissues of the body that resist disease-producing substances. In this sense the latter are called *antigens,* which term may be described as organic foreign substances, usually protein in nature, the biological products of animal or vegetable cells, whose introduction into the body stimulates the production by the body cells of a specific substance, the *antibody,* which neutralizes the antigen by uniting chemically with it. The side-chain theory explains the interaction of the various antigens and antibodies, and is largely supported by experimental evidence. These interactions are of a chemical nature. The antigen is not destroyed by the antibody, but the two are united in a chemical combination.

"Practically all pathogenic bacteria and protozoa act as antigens; many albuminous bodies, such as venoms, the enzymes, and bland proteins may also act as antigens. As the reaction is specific, it is possible to determine whether a particular organism is the true cause of a disease or not. On the other hand, if the antigen is known, the diagnosis may be made through the reaction of fixation, as in the case of syphilis and the Wassermann reaction." (Rosenau.)

The bactericidal properties of blood serum are due to substances, one of which joins the bacteria to the second substance. The former has been called the *intermediary body* (Ehrlich and Morgenroth), *substance sensibilisatrice* (Bordet), *fixateur* (Metchnikoff). The second substance is designated *alexin* (Buchner and Bordet), *cytase* (Metchnikoff), *complement* (Ehrlich and Morgenroth).

The intermediary body, or amboceptor, as it is also called, is relatively thermostabile, being inactivated at 68° to 70° C. The complement is thermolabile and destroyed by heat at 56° C. in thirty minutes. The amboceptor is readily attached to bacteria, but the complement is incapable of direct combination with the organisms.

The origin of complement has been in dispute. Metchnikoff thought it was a derivative of the leukocytes after death, during coagulation, while Buchner maintained that it was secreted by the living cells, and exists in the circulating blood. The latter is no doubt true, but bactericidal substances can be extracted directly from the leukocytes. Probably the body has other defensive factors still unknown, which possibly are present in all cells, but thus far the means at our command have only permitted the study of their production by the leukocytes.

As in *normal* serum, the bacteriolytic action is due to the activity of the complement and amboceptor, so in *immune* serum the destruction of bacteria depends upon complement and corresponding amboceptor. The stronger action of immune serum as compared with normal serum is owing to an increase in the amount of amboceptor; this increase in amboceptor follows the introduction of the corresponding bacteria, and the response is remarkably specific. (Simon.)

The formation of the specific immune amboceptors is according to a definite rule. A period of latency follows the injection of the corresponding bacteria; this in turn is followed by a critical ascent of the curve to a maximal point, then by a drop, at first abrupt, and later a gradual return to normal. The injection of dead bacteria produces the same result. A more or less prolonged power of resistance to the specific organism has been stimulated in the animal by the presence of the bacteria, an immunity, which may be quite lasting, as in cholera and typhoid.

The injection of bacteria produces in the serum of animals other changes in addition to developing bacteriolytic properties. Some organisms, typhoid bacilli, for example, cause the serum to agglutinate or clump the corresponding organisms. (Widal reaction.) This follows an attack of the disease and also the injection of dead bacteria (typhoid prophylactic vaccination). Diphtheria and tetanus bacilli introduced into the blood cause the formation of antitoxin in the serum which has the power to neutralize the toxins of the specific organism. When animals are infected with tubercle bacilli a certain reaction develops. When tuberculin, a derivative of the tubercle bacilli, is subsequently injected, the animal's temperature is raised.

The various reactions of animal bodies to the introduction of bacteria are expressions of the biological law that animal organisms invariably respond to the parenteral introduction of foreign animal and vegetable cells and their *protein* products by the formation of substances which have a tendency to neutralize, antagonize, or destroy the foreign substances that caused their production. This condition of altered power of reaction of animal bodies after being "treated" by the introduction of foreign protein matter is called *allergia,* and simply denotes a state of altered power of reaction.

The products formed in the treated body for its defense

FIG. 15.—THEORETIC FORMATION OF ANTITOXINS.

The central white area represents a molecule of a cell; the shaded portion represents the cell itself; the surrounding area represents the body-fluids about the cell.

1. A receptor of the molecule (first order); A, overproduction of receptors, which are being cast off; A2, a cast-off receptor free in the body-fluids—now an antitoxin; A3, a molecule of antitoxin combination with a toxin molecule T3. A3, a cast-off receptor still within the parent cell; T, a toxin molecule in combination with the receptor of a cell molecule; T2, a toxin molecule free in the body-fluids; T3, a toxin molecule in combination with antitoxin; T4, a molecule of toxoid (toxophore group lost). (*Kolmer, Infection Immunity and Specific Therapy, 2nd Edition. W. B. Saunder's Co.*)

are collectively known as the *antibodies.* The foreign proteins which cause their formation are the *antigens* or *allergens.*

Antitoxins. Antitoxins are antibodies formed in animals as the result of stimulation by specific toxins, and have the power of neutralizing the latter by chemical combination. By the injection of antitoxin generated in the serum of susceptible animals, preferably the horse, passive immunity may be secured and the curative properties of the serum utilized. When diphtheria antitoxin was discovered hopes were entertained that antitoxins for all the bacterial infections would be discovered—a desire which cannot be realized. The bacilli of diphtheria and tetanus—in which infections antitoxin treatment is most successful—have slight powers of invasion, and are readily destroyed by the serum and cells, though their toxins are very powerful and may kill the host after the infection, *per se*, is overcome, as normal serum has little or no antitoxin with which to neutralize the toxins. The animal immediately starts the formation of defenses, the antitoxins, but may be overcome, through lack of preparedness, before the defending forces are strong enough successfully to contend with the invading toxins. It is apparent from the foregoing that the creation of a passive immunity by the introduction of an extraneous antitoxin is the only available method of neutralizing the toxins.

If all the pathogens were toxin producers of low invading powers, the same brilliant success attained in treating diphtheria could be achieved in the other bacterial diseases. Unfortunately most of them either produce no toxin, or that produced possesses at the same time a high degree of invading power. It follows that even though the appropriate antitoxin be introduced, additional measures other than antitoxin are needed to turn back the invasion.

The only infections that are amenable to simple antitoxin treatment are those caused by Bacillus diphtheria, Bacillus tetani, and Bacillus botulinus. Other pathogens, the staphylococcus, Bacillus pyocyaneus, the spirillum of cholera, the typhoid, paratyphoid, and dysentery bacilli, the bacillus of symptomatic anthrax, and the plague bacillus are known or assumed to produce limited amounts of toxins, but for the above reasons give little or no response to antitoxic treatment.

Other substances of a poisonous nature when introduced into animals cause the formation of corresponding antitoxins which neutralize the substances causing their production. When the venoms of animals, including that of snakes, the phrynolysin of salamanders and toads, the arachnolysin of spiders, scorpions, and wasps, and the icthyotoxin of eels and other fish are introduced into animals, true antibodies, antitoxins, are produced. Some of the higher plants have antigenic qualities—such as ricin from the castor oil bean, abrin from the jequirity bean, crotin from croton seeds, and phallin of Amanita phalloides, the poisonous mushroom. Antitoxins may be obtained against the ferments of the body, pepsin, trypsin, steapsin, fibrin ferment, etc., and those of bacterial cultures.

The immunizing power of antitoxins is transitory, as they remain in the body only a short time, from ten days to two weeks. This passive immunity conferred by antitoxins must be renewed from time to time until the danger is past. As a therapeutic agent the antitoxin must be administered early, before the damage is done.

The Lysins. These are antibodies that disintegrate or dissolve cells and other organized structures. Bacteriolysins dissolve bacteria, hemolysins dissolve red blood cells, and cytolysins or cytotoxins dissolve epithelial and other body cells. The lysins themselves are non-toxic, but their activities form or set free poisonous substances; their chemical composition is unknown. They are different from antitoxins and agglutinins, and all three may be present in the same animal and be distinguished by biological, physical, and chemical tests.

Bacteriolysins are produced as the result of immunization (vaccination) with certain bacteria and cause dissolution of the specific organisms. The spirillum of Asiatic cholera, the typhoid and paratyphoid bacilli, the colon bacillus, Bacillus pyocyaneus, and the bacilli of dysentery, plague, and influenza are the pathogens most susceptible to bacteriolysis. This power of the bacteriolysins of dissolving the corresponding bacteria is known as Pfeiffer's phenomenon. Its discovery led to the further discovery of agglutination, and its practical application in the Widal reaction.

Bacteriolytic sera have little or no curative properties analogous to the antitoxic sera. While they can prevent infection when introduced into the body with the infecting organisms or soon thereafter, they have little or no power to combat an established infection. The reason for this is not clear. Apparently the organisms assume new characteristics and are no longer vulnerable to the bacteriolysins of the serum, therefore other means of defense must be relied upon.

Two substances take part in the process of bacteriolysis, one thermostabile, the other thermolabile. The former has been called the immune body, intermediary body, amboceptor, etc. The thermolabile substance is known as alexin, complement, cytase, etc. The complement is easily destroyed at 55° C., and is normally present in the blood, though it disappears spontaneously from serum in a few days, is probably formed by the breaking down of the leukocytes, and is not specific. The immune body is assumed to have two combining affinities, and is hence called the amboceptor, uniting the complement with the receptor of the cell. The amboceptor is more specific and stable than the agglutinins and the antitoxins, is destroyed in time at 70° C., and is of more importance in bacteriolytic immunity than the complement.

The exact function of the lysins in immunity is still obscure. Undoubtedly they do harm at times by liberating the endotoxins.

The hemolysins dissolve the red blood corpuscles and liberate the hemoglobin in solution, so-called laking of the blood, some of the stroma of the corpuscles being also destroyed. There are specific and non-specific hemolysins. The specific hemolysins are produced by immunizing one species of animal with the blood corpuscles of another. Non-specific hemolysins are distilled water, certain acids and alkalies, ricin and abrin, bacterial poisons, including tetanolysin and staphylolysin, venin, and the poison of scorpions.

Cytolysins or cytotoxins resemble bacteriolysins, hemolysins, and other lytic substances, and occur in the blood serum after animals are treated with the body or glandular cells of another species, causing the serum to dissolve the specific cells. Cytotoxins are produced by treatment with brain (neurotoxin), kidney (nephrotoxin), and other tissues; they are weak and feebly specific. At one time it was thought possible to dissolve foreign cells such as those of cancer by means of cytotoxins, a feat practically impossible owing to the feebleness and lack of specificity of the latter.

Isolysins possess the power of dissolving the red blood cells of the same species. They may be formed artificially in some animals, e. g., the goat, and occur naturally in man and in the horse. The existence of autohemolysins that dissolve human blood cells has been suggested. Their occurrence in paroxysms of hemoglobinuria has been surmised, but they have not been produced artificially.

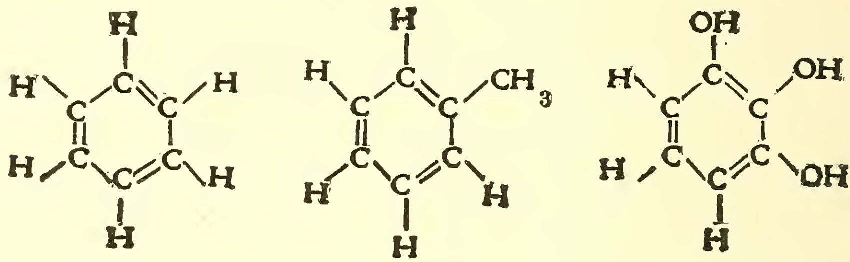
Agglutinins. These are antibodies which, when the sera containing them are mixed with emulsions of the specific organisms, cause agglutination or clumping of the bacteria, with loss of motility. The reaction is not absolutely specific, but the demonstration is simple, and the principle is utilized for diagnostic purposes, especially in typhoid fever (Widal reaction). With proper technic agglutination may be seen with the naked eye. The process does not kill the bacteria—in fact, they may multiply in the agglutinated state. The viability of the organisms is not a necessity, as the same result, clumping, is attained with dead cultures.

The chemical composition of agglutinins is undetermined. They are precipitated with the globulins by ammonium sulphate, and to that extent resemble antitoxin. They are only slightly resistant to putrefaction, dryness, and light, and are destroyed by heat at 65° to 70° C. and by acids. Protected from light and moisture they may be preserved in the dried serum. They are produced by injecting live or dead bacteria into a suitable animal, such as the rabbit, but occur spontaneously in some bacterial infections and continue for some time in the blood after convalescence. At first they are generally weak, but increase in strength with the progress of the disease until the serum will finally agglutinate in dilutions of 1/1000 or more. This reaction is useful in the recognition of the bacteria themselves, as well as for diagnosis. Bacteria, protozoa, including trypanosomes, and body cells, especially red blood cells, may be agglutinated.

We have very little insight into the significance of agglutination or the mechanism of the phenomenon. It appears to consist of two phases—the approach and the adhesion of the particles. Agglutination apparently does not favor phagocytosis. Large clumps of bacteria afford some mutual protection against bacteriolysis. Some investigators are now disposed to regard the agglutinating properties of sera as a manner of exposition of their precipitating powers. If such be the case, agglutinins should not be classified as antibodies.

Precipitins. Precipitins are antibodies that are formed when foreign animal or vegetable albumins—termed precipitinogens—are parenterally introduced into the body. When clear solutions of the precipitins and the corresponding antigens are added to one another, the mixture first becomes opalescent and then opaque, due to the formation of a precipitate that finally settles to the bottom of the test tube, leaving a clear, supernatant fluid. The precipitate is an insoluble combination of the *precipitin* and the *precipitinogen*, and is known as the *precipitum*—the latter being formed both within and without the body whenever antibody and antigen mix under suitable conditions, though the precipitums are not always visible.

Theoretically the precipitins and agglutinins are quite, if not entirely, similar, but practically they are put to different uses. The precipitins defy chemical analysis, and are precipitated with the globulins, which, in resistance to external and internal influences, they closely resemble. They are relatively specific. In the biological blood test the reaction is



Benzol C_6H_6 — Metacresol $C_6H_4(CH_3)$ (OH) — Pyrogallic acid $C_6H_3(OH)_3$

FIG. 16.—THE BENZOL RING.

used in determining the origin of blood stains. The relation of precipitins to immunity is obscure. They must have protective powers against the viruses of certain infections, as they throw them out of solution and render them inert and insoluble.

The Side-chain Theory. This stereochemical conception demonstrates graphically the production of antibodies and their specific effect. It shows the chemical interaction between the antigens and their antibodies, and that the former are neutralized and not destroyed by the latter. The microscopic structure of the cell is disregarded and the molecule of protoplasm assumed to have a central complex, upon which depends its life and activity, and "side-chains," "lateral chains," or "bonds," varying in number and combining capacities and serving purely vegetative functions. The benzol ring is the best graphic illustration of the theory.

These side-chains are known as *receptors,* some having specific affinity for molecules of food and others for toxic molecules. Receptors that will combine with toxins are formed in many parts of the body, more particularly in the organs and tissues which have the power to bind toxins without causing serious toxic effects. The toxin molecule is assumed to consist of two parts, the *toxophore* group and the *haptophore* group. The less stable toxophore group has a poisonous effect upon the cellular protoplasm. The haptophore group is the combining portion of the toxin molecule, and is assumed to have combining affinities for the receptors of certain cells, thus tending to explain the selective action of toxins. Toxins, especially that of diphtheria, at times lose their toxic properties, but retain the power to combine chemically with antitoxin, and are then known as toxoids. They have lost the toxophore group, but retained the haptophore group.

The best-known example of the interaction of toxin and antitoxin is in diphtheria. In the body the haptophore group of the toxin becomes anchored to the receptors of the cells, which are killed by the poison of the toxophore group, or else defend themselves by the reproduction of receptors. The continued stimulation of the cells by toxin causes an excessive production of receptors, which are thrown off and float free in the blood serum and body juices, and are known as free receptors, those remaining attached to the cells being spoken of as sessile receptors. The free receptors in the blood serum constitute antitoxin. Toxin now entering the blood is immediately neutralized by combination with the free receptors by means of their haptophore groups, or with sessile receptors that are thrown off together with the anchored toxin molecule. The cells are thus protected because all the combining affinities of the toxin are satisfied, the toxin being unable to unite with the remaining sessile receptors and the toxophore group unable to poison the cell.

The presence or absence of receptors properly "tuned" to combine with the toxin is factor that determines individual susceptibility to poisons and explains certain examples of natural immunity.

Some instances of combination of receptor and toxin occur by means of a second body, the amboceptor, immune body, preparative, desmon, fixative, sensitizer, or *Zwischenkörper*.

Structurally receptors, or haptins, as they are sometimes called, are divided into the first, second, and third orders. Those of the first order have only one combining or haptophoric group, by which they unite with the haptophoric group of the respective antigen—the class including the antitoxins, antiferments, tropins, and anticomplements. Receptors of the second order possess a haptophoric group for the corresponding antigen, and an *ergophoric* group which causes a further change in the anchored antigen. The agglutinins and precipitins belong to this order. The third order of receptors, called amboceptors, possesses two combining groups—one a haptophoric group that unites the antigen to the cell, and one which combines with the complement of the serum and is called the *complementophilic* group. An ergophilic group is not present. The complement of the serum causes the changes that occur after the union of antigen and antibody. This order includes all the cytotoxins (cytolysins), the immune opsonins and the lipoidophilic antibody (Wassermann).

Anaphylaxis. This is a condition of hypersusceptibility or altered power of reaction to foreign proteids on the part of animal organisms. It consists of a series of effects following a second injection of a specific protein into an animal that has been "sensitized" by a previous injection of the same protein. It has been described as the condition contrary to prophylaxis, but recent knowledge shows this to be incorrect, as immunity against some infectious diseases probably depends upon this altered power of reaction. It may be congenital or acquired, local or general; it is specific in nature, and can be produced by the introduction into the body of poisonous or non-poisonous proteins. Hypersusceptibility and immunity may co-exist in the same animal, the latter depending upon the former.

In vaccinia the incubation period of a second successful vaccination is shorter and less severe than that of the first. The ability of the organism to react is changed, "allergie" is established and protects the subject. The prophylaxis depends upon the anaphylaxis, and it therefore follows that there can be no *absolute* protection against smallpox and diseases of that class.

In the tuberculin and mallein reactions the subjects have been sensitized by the presence of the organisms of tuberculosis and glanders in the body, and react to the injection of substances that are non-poisonous to a non-infected person.

As a rule the symptoms of the phenomenon develop when the second injection is given at least twelve days after the first, and usually consist of convulsions and respiratory difficulty, sometimes followed by death. The symptoms can be caused only by the same protein that was originally injected. An animal sensitized to horse serum will not react to a later injection of egg-white.

If the second injection of protein is given before the twelfth day the symptoms of anaphylaxis will not occur. A condition of resistance or decreased susceptibility known as "anti-anaphylaxis" is established, which may be kept up by injections at short intervals. This is important in the continued use of antitoxic sera for preventive or curative purposes.

If the serum of an animal that has been sensitized—sufficient time being allowed for the formation of the proteolytic ferments—be introduced into a second animal, that animal will be sensitized to the given protein. Anaphylaxis will be caused by the injection into the second animal of the protein to which the first animal has been sensitized—an operation known as *passive anaphylaxis*.

The symptoms known as *serum sickness,* consisting usually of fever, kidney irritation, urticarial eruptions, and lymphatic nodular enlargements that sometimes follow the use of antitoxic sera, are largely of anaphylactic origin. These symptoms are usually of short duration, but deaths have occurred. They may follow one dose of serum if it is large, but a very small second injection may cause the symptoms. This is becoming comparatively rare with the use of the new, concentrated sera. Persons who give a history of horse-asthma are peculiarly susceptible to this sickness, being sensitized to horse protein.

The anaphylaxis reaction is utilized for diagnostic purposes. The tuberculin reactions of von Pirquet, Moro, Calmette, Wolf-Eisner, and others depend upon this phenomenon, as do the mallein reaction, a similar test in gonococcic infection, and Noguchi's luetin reaction in syphilis. It is used in legal medicine in the identification of blood stains and in laboratory practice as a most delicate test for minute amounts of protein.

Knowledge of the nature of this phenomenon has explained many phases of disease, among others the period of incubation of some of the communicable diseases. The incubation period of a number of these is from ten to fourteen days. It is probably more than a coincidence that this is the time required to sensitize animals with foreign proteins. The crisis of pneumonia, about the tenth day of the disease, is possibly open to the same explanation. Hay fever, various forms of asthma and urticarias are probably manifestations of local anaphylaxis. Dietary idiosyncrasies are examples of persons sensitized to sea-food, especially lobster, and to pork, strawberries, etc.

SPECIFIC IMMUNIZATION

Various degrees of active or passive immunity to certain diseases are now attainable by the introduction into the system of attenuated or killed microörganisms, a procedure known as *vaccination*, or by injection with immune antitoxic or antimicrobic sera from the blood of animals, generally horses.

The word *vaccine* is from the Latin *vacca* (cow), hence *vaccinia*, the cow disease. The term *vaccine* has unfortunately been applied to emulsions of dead or attenuated bacteria. This has created confusion, as the term *vaccine* is inseparably associated with cowpox virus or lymph. The term *bacterial vaccine* is now used to designate bacterial suspensions prepared for purposes of immunization. "There is no essential difference, however, between cowpox vaccine, which contains the modified germ or virus of smallpox in a diluent of lymph, and a bacterial vaccine containing the germ, modified by some physical or chemical agency in a diluent of saline solution or bouillon. It is, however, well to reserve the unqualified term 'vaccine' for cowpox virus, and to retain the designation 'bacterial vaccine' for suspensions of attenuated or dead bacteria. More recently the term *bacterin* has been applied to the latter, but this would imply an extract of bacteria, as, *e.g.*, tuberculin, which is not always the case." (Kolmer.)

"Some confusion likewise exists as regards the terms *serum* and *vaccine therapy*. *Serum therapy* is a process of *passive immunization* induced for either protective or curative purposes by the injection of the blood serum of another animal that has been actively immunized with bacterial toxins or the bacteria themselves, as, for instance, the injection of diphtheria or tetanus antitoxins. *Vaccine* or *bacterin* therapy is a process of active immunization brought about by the injection of the bacteria or their products directly into a patient. Bacterial vaccines that are simple emulsions of dead or attenuated bacteria are not, therefore, serums, and the indiscriminate use of the two terms is much to be regretted." (Kolmer.)

In preparing vaccines the specific microörganism or virus should be modified just sufficiently to deprive it of its disease-producing properties. The best vaccines are those in which the microörganisms have been exposed to just enough heat so that they can no longer multiply. The closer the vaccine approximates the live microörganism or virus, the more efficient it will be.

Immunity may be brought about by vaccination in the following ways:

1. *The living microörganism may be inoculated.* This is the method of choice but is still in the experimental stage. It is based upon the fact that an organism may be so introduced into an animal as to render it incapable of producing disease, but may, however, cause the production in the animal of specific protective antibodies. The typhoid bacillus will not produce typhoid fever unless introduced into the gastro-intestinal tract. The living bacilli, modified only to a slight extent by artificial cultivation, when injected subcutaneously produce a high degree of immunity and no ill effects. The method is now being tried on the chimpanzee.

2. *By inoculation with a modified virus or with microörganisms attenuated or modified according to various methods.*

(a) By passing the virus through a lower animal, as the passage of smallpox through the calf. The resulting virus is incapable of producing smallpox but does produce vaccinia which confers a specific immunity against smallpox.

(b) By exposing suspensions of microörganisms to heat. They are usually cultivated on a solid medium, then suspended in salt solution and exposed to a temperature at or just above their thermal death-point for just sufficient time to kill or attenuate them in so far that they cannot multiply. In the preparation of lipovaccines the bacterial mass or paste is dried in open dishes before being mixed with the oil suspension medium.

(c) By exposing the microörganism to air and light.

(d) By desiccating or drying the virus. This is the Pasteur method of vaccination in rabies. The virus contained in the spinal cords of rabbits is dried for varying lengths of time, emulsified, and injected. The longer the period of drying, the greater the attenuation, and in this manner the strength of the vaccine and the progress of immunization are under control.

(e) By exposing the microörganism to a high temperature for varying lengths of time. The several strengths of the anthrax vaccine for the immunization of lower animals is prepared by exposing suspensions of the bacilli to 42° C. for varying periods of time.

(f) By exposing the microörganisms of their products to certain chemical germicides. Some preparations of tuberculin and some anthrax vaccine and diphtheria and tetanus toxins are prepared in this manner.

3. *By inoculation with bacterial constituents, as the soluble toxins, bacterial extracts, and products of bacterial autolysis.* Koch's tuberculin T.R., Koch's old tuberculin, mallein, diphtheria and tetanus toxins, etc., are thus prepared. (Kolmer.)

Sensitized vaccines are those that have been exposed to the action of the respective anti-sera before their use. This procedure is intended to prepare the organisms by combining them with the homologous antibodies so that they have only to combine with the complement in order to begin their immunizing effect. This is theoretically correct but its practical value lacks full confirmation.

Smallpox. Immunity against smallpox is obtained by producing artificially a disease known as vaccinia by the injection of vaccine virus obtained from the calf. The disease is localized at first at the site of inoculation, and a vesicle forms. As a rule it does not become generalized. An active immunity against smallpox is created in the vaccinated subject. The unknown anti-bodies formed by the body cells as the result of vaccination remain for a long time in the body and may protect it for many years against the virulent forms of smallpox. A person suffering from smallpox cannot be vaccinated and the attack of smallpox renders him subsequently immune to vaccinia, just as vaccinia immunizes a person against smallpox.

The dried virus from human beings is no longer used in the process of vaccination, as in rare instances syphilis was transmitted in this manner. It is now the universal custom to use cow virus. This is obtained from vesicles in calves or young heifers about one week after the inoculation. The most potent material is in the pulp at the base of the vesicle and not in the lymph which exudes from the vesicle. The pulp is ground up and mixed with an equal amount of glycerine, which acts not only as a preservative but as a mild antiseptic for nonsporing bacteria. It is then stored for a month or more. After the pulp has been curetted from the inoculated skin of the abdomen of the calf the animal is autopsied to be sure that it is not diseased. The virus is tested for the organisms of pus and tetanus and for foot and mouth disease.

Vaccination is attended with some risk. Infection with streptococci or with the bacilli of tetanus sometimes follows. Both these infections may be due to contamination of the vesicle on the calf before the virus is removed, to dirty methods, or to contamination after vaccination, generally the latter.

Vaccination is a surgical operation and no person unfamiliar with surgical cleanliness should be allowed to perform it.

The site of the operation is usually the skin of the outer side of the upper arm, over the insertion of the deltoid muscle. Females are sometimes vaccinated on the outer side of the thigh or well above the knee on the inner aspect of the thigh. Vaccinations on the leg are more liable to secondary infections and mechanical violence and are only performed for cosmetic reasons.

Technic of Vaccination. The skin is washed with alcohol, followed by sterile water, and then dried without reddening. Any hyperemia should subside before the skin is abraded. The arm is grasped with the left hand of the operator and the skin rendered tense. Various methods are in use for removing the epidermis; it is frequently done over an area about an eighth of an inch square by a series of superficial and parallel scratches made with a sterilized needle or scalpel. Avoid bleeding; a surface that just oozes serum is the best, as it is essential that the virus be introduced through the epidermis so as to be absorbed by the lymphatics and blood vessels of the corium. The virus is then spread over this area and *thoroughly* rubbed in with a sterilized wooden tooth-pick or the vaccine point. The wound should be dressed with a light sterile gauze dressing after the lymph is dry.

Many of the best authorities prefer the method of incision. The incisions are best made with the point of a needle, and should be about an inch long and an inch apart. The vaccine virus is first placed upon the skin in two small droplets about an inch apart. The point of the needle is now moistened in the droplet and as the scratch is made the needle carries the virus along with it into the little wound. With the flat of the needle the virus should be gently rubbed (not ground) into the scratch. Any unnecessary irritation favors infections. (Rosenau.)

Cross-scarification or cross-scratching is open to the objection that it favors the growth of anaerobic bacteria under the crust or scab which forms over the abraded surface.

The simple method of puncture into the skin with a needle moistened with the vaccine virus gives little chance of infection, and the eruption is typical, but is less apt to take as the virus now in use is diluted with glycerine and therefore attenuated.

Protection of the wound with several layers of dry sterile gauze held in place with adhesive plaster is preferable to pads, plasters or shields, as these, by retaining heat and moisture, cause a softening and breaking down of the crust. Bathing and the ordinary use of the arm need not be omitted, but its unnecessary use must be carefully guarded against.

Dependence should not be placed on one inoculation of the virus. Especially in times of epidemics and known exposure two or more inoculations should be made at the same time. This not only insures a successful result but rapidly immunizes the patient.

Typhoid Fever. The excellent results attained by typhoid immunization in the military services of the belligerent powers during the Great War leave no doubt as to its value and practicability. The procedure is harmless and the protection afforded is effective under all conditions. Typhoid prophylactic therapy cannot be as general in civilian practice as vaccination against smallpox, as the vaccine must be administered subcutaneously and more than one dose is necessary. However the laity should be educated as to its value and State and city boards of health should offer the prophylactic free of charge in order to immunize as large a proportion of the community as possible. All physicians, nurses, attendants in hospitals and other public institutions should be immunized. Typhoid vaccination should be obligatory on all applicants for admission to training schools for nurses. All inmates of asylums, homes, and other public institutions under forty-five years of age should be immunized, and, if necessary, the State should furnish the vaccine. Physicians should strongly advise immunization upon all members of a family when there is a typhoid patient among them, also all those about to leave their homes for a vacation in some neighboring seashore or mountain resort, and, in times of epidemics of typhoid, upon all those over whom they have any influence.

The immunity following typhoid immunization is not absolute. A large dose of infectious material or a lowered state of bodily resistance may result in infection. Therefore immunized persons should not neglect the ordinary hygienic and sanitary precautions against this dangerous disease.

It was formerly believed that a negative phase followed the inoculation. This is now thought to be incorrect and that the immunity manifests itself soon after the first and it is believed second doses have been given. The duration of the immunity is not known definitely but the consensus of opinion is that it begins to decline in about two and one-half years after inoculation. Doubtless some measure of protection remains even after four or five years.

Preventive typhoid inoculations consist in inducing artificially an active immunity to typhoid fever by introducing dead typhoid bacilli into the subcutaneous tissue. The vaccine should be prepared from typhoid bacilli as little changed by heat or chemicals as possible. The bacilli are grown on agar for twenty-four hours, washed off with sterile normal salt solution, standardized by counting the bacilli, and killed by heating to 56° C. for one hour. As an additional precaution, 0.25 per cent. of tricresol is then added. Stitt states that typhoid vaccines sterilized with 0.5 per cent. of phenol appear to keep longer and to have a higher immunizing power than those prepared by sterilization with heat and subsequent addition of the antiseptic. The vaccine is usually prepared in two strengths: 500,000,000 bacteria per cubic centimeter for the first dose, and 1,000,000,000 for the second and third doses. The three injections are given at intervals of ten days. This is the method originally in use in the American Army. The Medical Departments of the Army and of the Navy now use a triple vaccine made up of 1,000,000,000 typhoid bacilli, 750,000,000 paratyphoid A bacilli and 750,000,000 paratyphoid B organisms in 1 c.c. of the vaccine. The first dose is 0.5 c.c., the second and third doses are 1 c.c. each. The triple vaccine is inoculated subcutaneously at intervals of one week.

Method of Inoculation. It is advisable to give a cathartic the day before the inoculation is made. If the vaccine is administered about 4 o'clock in the afternoon the reaction occurs during the night and causes less discomfort. Inoculations should not be made during the menstrual period, as the general reaction is likely to be somewhat severer at this time;

neither should they be made if the temperature is above normal.

The injections should be made over the insertion of the deltoid muscle. The site of the inoculation should be sterilized with tincture of iodine and the injection given *subcutaneously*. No dressing is necessary. The syringe and needle should be sterile. When a number of inoculations are to be made at one time, a single syringe may be used with a number of sterile needles, a separate needle being used for each person. The prophylactic is now on the market in syringes with sterilized needles, with instructions as to the technic of administration. The prophylactic is preferably dispensed in individual ampules, though it is sometimes furnished in stock bottles.

Inoculated persons should abstain from severe exercise for twenty-four hours. The local reaction lasts about forty-eight hours and consists of a small red and tender area, though occasionally edema and pain may be more marked. Abscesses seldom occur. The general reaction may be absent or quite severe; when present there is headache, malaise, and sometimes fever, chills, and rarely nausea, vomiting, or diarrhea. The most severe reactions are no cause for alarm and are of short duration. Those in poor physical condition are more likely than the robust to experience severe reactions.

Paratyphoid Fever. In this country it is estimated that from 2 to 4 per cent. of the cases reported as typhoid can be shown by bacteriological examination to be paratyphoid infections. About 80 per cent. of these cases are due to Bacillus paratyphosus B. Immunization with the paratyphoid bacilli is generally done in conjunction with typhoid immunization in the triple vaccine as described above, but separate vaccines which are administered in the same manner are available. The first dose contains 500,000,000 Bacillus paratyphosus A and 300,000,000 Bacillus paratyphosus B; the second and third doses are the same, and contain 1,000,000,000 Bacillus paratyphosus A and 600,000,000 Bacillus paratyphosus B.

Typhus Fever. Prophylactic immunization with Bacillus typhi exanthematici is still in the experimental stage but the outlook is promising. The work of Plotz and others seems to indicate that a vaccine of this bacillus is capable of reducing the incidence of the disease but does not produce an absolute immunity to typhus fever. The vaccine is polyvalent and is sterilized by heating to 58° to 60° C. for from half an hour to one hour. It is preserved with 0.5 per cent. phenol or tricresol. Each cubic centimeter of the vaccine contains about 2,000,000,000 bacteria. Three injections consisting of 0.5, 1, and 1 c.c., respectively, are given at five or six day intervals.

Bacillary Dysentery. Protective vaccination against bacillary dysentery has not as yet yielded satisfactory results. Shiga reports that mixed active and passive immunization (vaccine plus immune serum) did not decrease the number of infections but did lower the mortality among 10,000 vaccinated persons. The number of types of the dysentery bacillus and the severe reaction following the injection of the toxic vaccine have made the practice of protective inoculation for bacillary dysentery very difficult.

Antitoxin has been prepared for the Shiga type of dysentery bacilli, which has yielded fairly satisfactory results in the prophylaxis and cure of this variety of the disease. Antiserums for the Flexner type have not proved of much value. This is explained by the fact that the Shiga type produces an extracellular toxin and the Flexner type does not. In this country the serum treatment of infantile diarrheas and true dysenteries, many of which are caused by the Flexner type of the dysentery bacillus, has proved disappointing.

The best serums are prepared by injecting both toxins and bacilli, producing a serum that is essentially antitoxic and bactericidal in action. Several strains of dysentery bacilli should be used, in order that a polyvalent serum may be prepared.

The prophylactic value of antidysenteric serum is slight, but it frequently exerts a curative action and should be available for use in institutions and armies when there is danger of an epidemic of dysentery.

The dose for prophylactic purposes is usually from 10 to 20 c.c. The protection afforded is only of short duration, therefore the injection should be repeated after two or three weeks. For curative purposes Shiga recommends doses of from 10 to 60 c.c., according to the severity of the case.

"When the serum is used during an epidemic, it is advisable to ascertain beforehand the nature of the infection, as the antiserum for the Shiga bacillus is highly specific and is not likely to prove of value in the treatment of infections caused by the Flexner type of bacillus. Otherwise a polyvalent serum should be used." (Kolmer: Infection, Immunity and Specific Therapy.)

Whitmore reports most favorable results from the use of dysentery lipovaccines. The vaccine contains 3 billion Shiga organisms, about the same content of "Y" organisms, and about 2 billion Flexner type bacilli in 1 c.c. of the lipovaccine. Such a vaccine gives rise to no more general reaction than does the triple typhoid one in saline. (Stitt.)

Cholera. Inoculation with cholera prophylactic vaccine confers some active immunity, but this is far from absolute. It diminishes the liability of inoculated persons to cholera, but has less influence on the mortality when the disease occurs in those who have been vaccinated. Favorable results were attained in India by the use of Haffkine's method of the subcutaneous injection of live cholera spirilla. Vaccines are now prepared from heat-killed cultures. An emulsion of the spirilla in salt solution or a bouillon culture is subjected to a temperature of 54° C. for one hour. Three doses are injected seven to ten days apart, going from 500,000,000 to 2,000,000,000. The immunity produced lasts at least a year.

The local and constitutional effects may be quite severe.

There is more or less pain and edema, which subsides in twenty-four hours. The constitutional effects are marked by malaise, fever (100°-101° F.), nausea and vomiting, followed the next day in about 10 per cent of persons by transient diarrhea. Usually all symptoms have disappeared within seventy-four hours. (Kolmer.)

Strong has proposed the use of the products obtained by "autolytic digestion" of the cholera organism, i.e., by incubating an emulsion of them in sterile water, in which they break up spontaneously. The cultures are killed at 60° C. and then allowed to digest themselves in the incubator at 37° C. for three or four days (peptonization). The preparation is then filtered and from 2 to 5 c.c. of the filtrate is injected.

Protective inoculations against cholera can never be popular and are not necessary in communities with good sanitation. Their chief value is in camps, armies operating in infected districts, ships visiting infected ports, and for physicians, nurses, and others especially exposed.

The reports from the use of anticholera sera are not encouraging.

Plague. Active artificial immunity may be produced by vaccination with cultures of the bacillus pestis. The most successful method is that of Haffkine. The prophylactic consists of a killed culture which is injected subcutaneously. Stalactite bouillon cultures of plague are cultivated in flasks at from 25° to 30° C. for five to six weeks. These are sterilized by heating at 65° C. for from one to two hours; 0.5 per cent. of phenol is added and the preparation tested for sterility by culture. If found sterile, it is decanted in small vials of from 10 to 30 c.c. capacity. Colonel Strong has prepared a prophylactic vaccine from living plague cultures of greatly reduced virulence.

The ordinary dose of Haffkine's prophylactic is from 3 to 3.5 c.c. for males and from 2 to 2.5 c.c. for females. Larger quantities have been given without harmful results. The injections are given in the same manner as the typhoid vaccine and the local and constitutional effects are similar but slightly more intense. They pass off in about twenty-four hours, during which time the patient should rest.

The immunity does not become effective until a few days after inoculation; its duration is uncertain but probably lasts for a number of weeks, possibly for months. The prophylactic is not an absolute protection against the disease but does sensibly diminish the incidence of attacks of plague. The mortality among the inoculated is much lower than among the non-immunized. As the immunity is of relatively short duration, the good results are not so readily appreciated when the disease is endemic. The best results are attained during epidemics, when the protection afforded lasts until the danger is past. At such times inoculations should be repeated at least two or three times a year. The prophylactic does little or no good in the pneumonic variety of plague but in the bubonic variety the results are most encouraging.

Plague vaccination is of value chiefly for the protection of physicians, nurses and others who are exposed. The personnel of rat brigades, plague laboratories and quarantine stations should be protected by this method. It is valuable in the protection of small civil communities, the crews of naval and merchant ships, and military organizations.

Yersin's antitoxic plague serum produces a certain amount of passive immunity and has slight curative power. The protection lasts only about three or four weeks. To be of any value large quantities of the serum must be administered early in the disease. It is made by injecting horses with dead plague cultures and afterward with living ones.

Pneumonia. Recent improvements in technic have demonstrated that a certain degree of protection, at any rate, can be secured against pneumococcus infections by inoculation with a corresponding vaccine. The results of the work of

Lister in South Africa and of that of the American army surgeons in the camps in the United States were such as to leave no doubt that protection can be afforded in this manner, for it was found not only that there was a definite decrease in the incidence and mortality from pneumonia, but—and most important of all—that the diminution in the incidence corresponded to the type of the vaccine which was employed. The vaccine used at Camp Upton by Cecil and Austin was made up from strains I, II, and III. The inoculations were made subcutaneously at intervals of five to seven days, 3,000,000,000 (one of each kind) being given the first time, 6,000,000,000 (two of each) the second time, 7,500,000,000 (3 each of types I and II, and 1½ of type III) the third time and the same dose the fourth time. This vaccine apparently also had a protective effect against type IV of the pneumococcus and afforded a marked protection against streptococcus pneumonia. During the recent epidemic of influenza the Army medical officers made use of a triple pneumococcus vaccine on a large scale for prophylactic purposes, but the data from which conclusions can be drawn are not yet available. It is clearly indicated, however, that at last a very definite advance has been made toward the conquest of this scourge. (Simon: Human Infection Carriers.)

The results of the treatment of pneumonia by serum made from the type of pneumococcus causing the case are most encouraging. The presence of types I or II, which cause the majority of infections, is determined by the agglutination test, and the serum corresponding to the type found is administered. To obtain the best results the serum should be given as early as possible and intravenously. Small doses given subcutaneously are almost devoid of effect. The Rockefeller Institute procedure consists in injecting 0.5 c.c. of serum subcutaneously to discover if hypersensitiveness exists and to produce anti-anaphylaxis. The intravenous dose is 50 to 100 c.c. of the serum, diluted one-half with salt solution. The condition of the patient serves as a guide in the later treatment. One injection is not sufficient to bring about a crisis. The reports so far show that the serum apparently lessens the degree of intoxication, and, except in the fatal cases, lowers the temperature and shortens the course of the disease.

The antipneumococcus serum is prepared by immunizing horses with dead cultures and then with virulent living cultures. In order that the serum should possess some antitoxic value, it is desirable that the animals be immunized also with autolysates. In the Rockefeller Institute different horses are immunized with strains belonging to types I and II. If further studies continue to show that 65 per cent. of infections are caused by organisms belonging to these groups it will be necessary to produce a potent polyvalent serum, and this appears to be quite possible.

Influenza. Vaccination against influenza has not as yet proved successful, but encouraging results are reported from the use of the serum of convalescents. During epidemics of influenza it is a wise measure to vaccinate against the complicating pneumococcus and streptococcus pneumonias.

Tuberculosis. A vaccine that will give complete immunization against the tubercle bacillus and all its products, in addition to producing a healing focal reaction of the right degree, has yet to be discovered. The tuberculins are not adapted for prophylaxis because they possess only partial immunizing powers. These effects, however, may be of some assistance to the infected subject, in addition to producing a focal reaction of value in walling off a lesion and producing local antibodies. (Kolmer.)

The filtrates from cultures of tubercle bacilli have little toxic effect, therefore it is assumed that the toxin is intracellular.

Koch's "Old Tuberculin" is simply a concentrated 5 per cent. glycerine bouillon culture. It is now principally used for diagnostic purposes.

In Koch's "New Tuberculin" or tuberculin "R" virulent bacilli are dried in vacuo and ground up until stained smears fail to show intact bacilli. One gram of such material is triturated with 100 c.c. water and centrifugalized. The supernatant fluid is removed and is designated "T. O." The residue is then dried, triturated in water and centrifugalized. Subsequent trituration and centrifugalization, preserving each time the supernatant suspension, gives the new tuberculin. It has been found at times to contain virulent tubercle bacilli.

Koch's bacilli emulsion is simply a suspension of ground-up bacilli in 50 per cent glycerine solution. It is practically "T. O." and "T. R." combined and contains 5 mg. of bacillary substance in 1 c.c.

The bouillon filtrate of Denys is the unheated Chamberland filtrate of broth cultures of human tubercle bacilli to which has been added ¼ per cent. phenol.

In the treatment of tuberculosis T. R. and the bacilli emulsion are used in doses of from 1/4000 mg. to 1/1000 mg. These products come in 1 c.c. bottles containing 5 mg. of bacillary material. It is convenient to remove 2/10 c.c. containing 1 mg. Add this to 10 c.c. of glycerine salt solution with ¼ per cent. lysol. Each c.c. contains 1/10 mg. One c.c. of this stock solution added to 99 c.c. of salt solution, with ¼ per cent. of lysol, would give a working solution, each c.c. of which would contain 1/1000 mg. of tuberculin. (Stitt.)

Cerebrospinal Fever. According to Sophian and Black an active immunization may be induced by inoculating killed cultures of the meningococcus. The injection of the dead cultures confers a considerable immunity. This method is of service in the treatment of chronic carriers and may prove to be of value in personal prophylaxis. One million bacteria are injected at the first dose, 7 days later the same number, and 7 days later 2,000,000.

Antimeningococcus serum is not practical as a preventive, but is useful in the treatment of cerebrospinal fever. The method of intraspinous inoculation of the serum after removal of spinal fluid is the one in current use to-day.

"The action of the serum seems very largely to be an opsonic one, in that, under the influences of the serum, a powerful phagocytosis of the meningococci takes place. It is also possible that to a certain extent bactericidal action participates, in that the injection of the serum into the closed space may give rise to a sort of intraspinous Pfeiffer reaction with energetic ingestion of the bacteria by leukocytes." (Zinsser: Infection and Resistance.)

Flexner obtains the serum in the following manner: Initial injections of killed cultures followed by alternate injections of living meningococci are made into horses, then seven days later an autolysate made from different strains; seven days later living meningococci are again injected; thus alternating the material every week. The immunization requires about one year but more recently it has been possible to greatly shorten this period. (Stitt.)

In treating cerebrospinal fever, spinal fluid is withdrawn until the pressure is relieved and the fluid comes out at the rate of 4 or 5 drops per minute. The needle is left in place and serum in amount equal to about ½ the spinal fluid removed is injected. The injections must be repeated according to the symptoms. Intravenously the dose is 50 to 100 c.c.

The use of antimeningococcus serum has reduced the mortality of this disease from about 75 per cent. to below 30 per cent.

Diphtheria. A passive immunity will usually be conferred by the subcutaneous administration of relatively small doses of antitoxin serum. By its use antibodies (antitoxin and opsonin), which neutralize the toxin as rapidly as it is produced and aid in the destruction of the diphtheria bacilli, are introduced into the body-fluids. The duration of this passive immunity is relatively short, as the antitoxin is rapidly eliminated. It usually lasts from two to four weeks, which however is generally sufficient, since the incubation period of diphtheria is only a matter of a few days.

The dose is 500 units for infants under one year of age and 1000 to 1500 units for older children and adults.

All persons who have come in intimate contact with a case of diphtheria should be immunized. Time permitting, the Schick test should be applied and the antitoxin only given to those showing positive reactions. It is especially valuable in families and institutions. All members of a family in which a case of diphtheria occurs should be immunized. Secondary cases are practically *nil* in homes from which cases are promptly removed and the remaining members of the family promptly immunized.

The methods of preparing and standardizing diphtheria anti-toxin are briefly as follows: A strong toxin is prepared by cultivating a virulent strain of the bacillus in a suitable broth for ten days or two weeks; the culture is then passed through a porcelain filter, which retains the bacilli, the filtrate being a strong solution of toxin. This is standardized by determining its action upon guinea-pigs, the *minimal lethal dose* (M. L. D.) of *toxin unit* being the amount of toxin that will cause the death of a 250-gram guinea-pig in four days. Horses that have been tested with tuberculin and mallein and found free from tuberculosis and glanders are used in the preparation of the antitoxin. The broth filtrate or toxin is injected subcutaneously at weekly intervals for a period of three or four months. When each c.c. of the serum of the horse is found to contain about 250 to 500 antitoxin units the animal is bled from the jugular vein. Some sera contain as much as 1,300 units in a cubic centimeter. Some manufacturers concentrate and purify the antitoxin. Their methods are based upon the principle that the antitoxin in the horse serum is precipitated with the globulins which come down on half saturation with ammonium sulphate. In this way, as the content in horse-serum proteids is lessened, the anaphylactic dangers are lessened.

The *antitoxic unit* is the smallest amount of serum that will just neutralize 100 times the minimal lethal dose of toxin for a 250-gram guinea-pig. The adoption of this standard has secured some accuracy in dosage.

A more lasting (active) immunity than that conferred by antitoxin may be given by treating the individual with the diphtheria toxin-antitoxin mixture. In this 8 / 10 of one L + (fatal dose) of toxin is overneutralized by one unit of diphtheria antitoxin and the serum so prepared is injected in 1 c. c. quantities subcutaneously. Three injections at intervals of about five days are required for immunization. The toxin-antitoxin mixture can be bought ready for injection. In an epidemic one could first give an immediate prophylactic injection of antitoxin to be followed by 3 injections at five-day intervals of the toxin-antitoxin immunizing mixture. Immunity is acquired in about 2 months. (Stitt.)

The successful treatment of diphtheria by antitoxin is one of the great triumphs of modern medicine. When it is used on the first day of the disease, practically no mortality occurs. It is very necessary to get antitoxin into the circulation as soon as possible after infection has occurred. This is accomplished by giving antitoxin to every patient even suspected of being diphtheric, and making the diagnosis afterward, and by administering the antitoxin in such a manner as to favor quick absorption. For this reason intramuscular and intravenous injection should be resorted to in all severe cases. (Kolmer.)

Antitoxin is usually injected into the tissues of the back, abdomen, or buttocks. It requires about forty-eight hours for complete absorption, but improvement is frequently observed in less than twenty-four hours after injection. The usual dose, as a curative measure, is from 2,500 to 5,000 units. If the treatment is delayed or the case very severe the dose should be 10,000 units. As much as 50,000 units have been given in very severe cases.

Tetanus. Tetanus antitoxin has proved of great value in the prevention of lockjaw, especially in military surgery. Opinions vary regarding its curative value but the experience of recent years shows quite conclusively that tetanus antitoxin does possess these powers, and is of distinct aid in the treatment of tetanus.

The antitoxin is produced by gradually immunizing horses with increasing doses of tetanus toxin, following a preliminary dose of 5,000 antitoxin units, until the blood of the animals contains the antitoxin in sufficient quantities for therapeutic purposes. The animals are then bled under aseptic conditions, the serum decanted, and this, with a small amount of preservative, is the antitoxin as administered to patients. Concentrated antitoxin is now on the market and is a desirable improvement.

The standardization of tetanus antitoxin is important. Rosenau has established the American unit as the amount of antitoxin required just to neutralize 1,000 fatal doses of tetanus toxin for a 350-gram guinea-pig. The Federal Government has adopted this unit, and supplies the different producers with standardized toxin for testing the antitoxin. This unit is ten times as neutralizing as the diphtheria antitoxin one.

As a prophylactic tetanus antitoxin is of greater value than diphtheria antitoxin but therapeutically it is far inferior to the latter, for the reason that the toxin produced by the tetanus bacilli soon unites with the nerve cells of the spinal cord, where it is difficult or impossible for the antitoxin to effect its neutralization. To be of value in the treatment of tetanus, antitoxin must neutralize all free toxin as quickly as it is secreted and before it is absorbed by the nervous tissue and must disassociate or neutralize some of the toxin "loosely united" with nerve-cells or suspended in the lymph after it has left the capillaries and before it is taken up by the nerve-cells. (Kolmer.)

Tetanus antitoxin is a trustworthy preventive but it must be correctly administered to achieve satisfactory results. It should be given as soon as possible after the infliction of the wound, preferably as part of the primary treatment. The antitoxin should be injected as near the wound as possible. Fifteen hundred units of antitoxin are generally administered as the first prophylactic dose. It should, if possible, be injected intramuscularly, so that the motor nerves may absorb it rapidly. Antitoxin should be injected into nerves exposed in the wound. The serum is rapidly eliminated from the system in from eight to ten days after the injection is administered, and, as it is essential for the success of the treatment that the antitoxin be present in the body for two or three weeks after the receipt of the injury, a second intramuscular injection of 1,000 units of antitoxin should be given about the end of the first week and a similar dose at the end of the second week. Serum sickness occasionally develops but the symptoms are not dangerous.

If the wound is not seen by the surgeon until several days after the injury has been inflicted, it should be freely opened and dressed, and, in addition to the intramuscular injection of 1,500 units of antitoxin in the neighborhood of the wound, 5,000 or 10,000 additional units should be injected intravenously. This is indicated for the reason that it requires at least twenty-four hours for the antitoxin to be absorbed from the subcutaneous tissues, and immediate neutralization of any toxin present in the blood may favorably influence the prognosis of an attack of tetanus.

In order to be of value in the specific treatment of tetanus the serum must be given in doses several hundred times the size required merely for protective purposes, and it must be injected within thirty-six hours after the onset of the disease.

The case mortality has been reduced from about 80 to about 60 per cent by the use of the serum treatment.

The proper administration of the antitoxin is most important. The maximum amount should be given as soon as possible, and the greater the delay in giving it, the greater is the amount required. Ten thousand to 20,000 units of antitoxin must be administered *intravenously* at once, and the dose repeated if no effect is apparent or if the good effect wears off in eighteen to twenty-four hours. After one or two intravenous injections the good effect may be maintained by direct intramuscular injections of from 500 to 10,000 units for one or two doses. From 300 to 5,000 units should be given *intraspinally* by means of lumbar puncture. This dose should be repeated every twenty-four hours unless the symptoms have markedly ameliorated.

If a surgeon is at hand, from 500 to 1,000 units of antitoxin should be slowly injected intravenously into the sheaths of the nerve trunks leading from the infected region. These injections are directed to be made as near the trunk as possible, and to distend the nerve so as partly to neutralize and partly mechanically to interrupt the passage of toxin to the cord or brain. (Kolmer.)

Rabies. Pasteur discovered that rabies may be prevented by conferring gradual immunization with increasing doses of the attenuated virus. The production of rabic antibodies is stimulated by injecting attenuated or modified virus during the period of incubation. Thus the virus introduced into the wound is destroyed, neutralized, or its effects neutralized, while the virus itself is finally destroyed. The virus is passed through a series of rabbits, which process shortens the period of incubation to about six or seven days and also lessens its pathogenicity for man. This modified virus is known as *virus fixé*. The fixed virus is attenuated by drying the tissues in which it is contained, and it is possible to modify this virus so that it cannot produce rabies in man, but yet is able to produce the specific antibodies.

The Pasteur treatment is a process of active immunization with emulsions of the spinal cords of infected rabbits in which the virus has been attenuated by drying and desiccation over caustic potash at a temperature of 23° C. The cord is divided into segments about 1 inch in length. After drying, pieces of the cord are prepared for subcutaneous injection by emulsifying them in sterile saline solution in an aseptic manner. No attempt at exact dosage is made. The material may be preserved for shipment by the addition of 20 per cent. of glycerine and 0.5 per cent. of phenol.

The uniform dose of cord emulsion is 2.5 c. c. The injections are given subcutaneously in the abdominal region. The injection may be followed by redness and induration in the subcutaneous tissues, but abscesses are never formed if aseptic precautions are taken. The treatment lasts about twenty days. Severe injuries should be rapidly immunized by intensive treatment; in other cases the treatment may be mild.

The value of the Pasteur treatment has been proven beyond a doubt. The mortality of rabies without the treatment is about 16 per cent.; with the treatment the average mortality is about 0.46 per cent.

CHAPTER III

DISSEMINATION OF COMMUNICABLE DISEASES

General Considerations. For the successful practice of preventive medicine an accurate knowledge of the methods by which the exciting causes of communicable diseases are transmitted is absolutely essential. This includes a careful study of the modes of entrance into and egress from the body of the agents of infection, and of the means by which they are carried from person to person and from place to place.

Formerly great importance was attached to aërial and fomites infection. It is now known that these methods play a very minor part in the dissemination of communicable diseases.

Views concerning the growth of disease germs outside of the body have also undergone radical changes of late years. Recent research has shown that the saprophytic existence of pathogenic microörganisms is not an important factor in the spread of disease. The belief is strong among the laity that most infectious diseases have their origin outside the body, presumably in filth, the eradication of which idea is of primary importance in teaching personal and municipal hygiene to the public. It must be taught that persons, not things, transmit disease.

The following-named organisms may develop in the soil, but there is little or no evidence that they commonly do: *Bacillus anthracis, Bacillus tetani,* pus-forming bacteria.

The following have a limited saprophytic existence, but this is probably very unusual: *Bacillus typhosus, Bacillus cholera Asiatiacæ, Bacillus pestis bubonicæ, Bacillus dysen-*

teriæ, Amœba dysenteriæ. In temperate climates such a source of these diseases is a very small factor in their development.

Probably *Bacillus diphtheriæ* has a limited saprophytic growth in milk.

There is not the slightest evidence that the specific organisms of the following diseases ever develop outside the bodies of animals: Tuberculosis, pneumonia, influenza, cerebrospinal meningitis, scarlet fever, typhus fever, smallpox, whooping cough, gonorrhea, syphilis, malaria, yellow fever, sleeping sickness.

Communicable diseases are almost always transmitted from one person to another by direct or indirect contact with cases, carriers, or contacts or by insects, food, or drink.

A most important step in the development of preventive medicine was the recognition of carriers, or persons who carry about and disseminate the germs of infectious diseases without themselves manifesting recognizable signs of the infection. Carriers and mild, irregular, unrecognized, and ambulant cases and contacts are usually responsible for outbreaks of infectious disease, the origin of which cannot be explained.

In ancient times the importance of personal cleanliness and fresh air as prophylactic measures was recognized. The Levitical laws relating to sanitation were based chiefly on cleanliness, and are still of value. Succeeding methods, until the discovery of the germ origin of disease placed sanitation and hygiene on a scientific basis, were largely theoretical and empirical, when not absolutely farcical or fantastic.

An accurate knowledge of the stage of an infectious disease in which the danger of its transmission is greatest is very important. Definite facts on this point are hard to obtain, as the specific organisms of some of the common diseases are unknown. The period of desquamation was, until very recently, considered the most dangerous stage of the exanthemata, but this theory has been largely discredited.

Scarlatina and measles have been proven to be contagious only in the early or catarrhal stages, and in the later stages only if discharges are present.

Some of the modes of disease transmission seem to be unavoidable incidents of human existence. Many are preventable and others may be reduced to a minimum.

Contact Infection. By the term contact infection is meant the transference of fresh or quite fresh infectious material from one person to another. It may be direct, as by actual contact between the sick and well, or indirect—some infected person or thing acting as intermediary. The distinction between indirect contact infection and infection by fomites is not sharp, but is nevertheless practical and reasonable. In infection by fomites there is a more or less definite interval of time in which the *materies morbi* may become dry, while in indirect contact infection only a short period elapses between the contamination of the intermediary agent and the infection of the well person. The transference of gonorrheal pus on a syringe is an example of indirect contact infection, while the dissemination of anthrax by a garment made from the skin of an infected sheep demonstrates infection by fomites.

It is now a well-established fact that the more or less direct transfer of infective material from person to person is the principal means of the dissemination of communicable diseases. In the first place it is the most obvious mode. Many of the communicable diseases with which we are most familiar, especially the exanthemata and diphtheria, spread in dwellings and hospitals only by contact. Even in filthy and poorly ventilated tenement houses they are not readily carried from family to family if the members of the infected family do not come in contact with their neighbors, and this holds true in spite of the use of common doors, hallways, and water-closets. Cases of cross infection continually occur in hospitals where communicable diseases are treated on the old theory of air infection and the new doctrine of medical asepsis is neglected. In some French and English hospitals the contagious cases are treated in the general wards, a screen or possibly only a cord or tape surrounding the bed serving as a label or reminder that the enclosed patient is a contagious case. In these hospitals the most rigid medical asepsis is practiced: the nurses always sterilize their hands after waiting on a patient; when anything is done that would be likely to infect her clothing, a gown is worn which is kept in the room or enclosure; nothing goes into the confined space that is not sterile, and nothing comes out without being at once sterilized. The same care must be taken that prevails in a bacteriological laboratory.

Formerly undue importance was attached to other modes of infection, first by air and then by water and milk. In typhoid fever especially this view was enhanced by the striking manner in which now classical epidemics were proved to be due to infected water and milk supplies. The erroneous idea that typhoid fever is an intestinal disease gave weight to the belief that it was almost always transmitted by water.

Infection by contact with persons or things grossly contaminated with infectious excretions and secretions in such diseases as cholera, dysentery, typhoid, and gonorrhea, is generally avoided by even the most careless. It is occult contamination by the above and by infectious oral and nasal secretions and sputum that spreads the germs of disease.

The opportunities for the dissemination of germs by direct and indirect contact are countless. The average human being of even ordinarily cleanly habits is not as clean as he himself supposes. Human fingers and everything that the fingers touch are frequently contaminated with fecal matter and saliva and nasal secretions. The colon bacillus, which is a good index of the presence of excrement, is found on the hands of from 5 to 10 per cent. of fairly clean people. When one considers the hundreds of times daily that the hands of the average person go to his mouth and nose, the danger from this source is obvious. Privies and water-closets, especially in public places, are generally contaminated with feces or urine, and are frequently in horrible condition. Only in the higher classes of residences and hotels are the toilets kept in even an apparently sanitary condition. The proportion of the entire population who always wash the hands after a bowel movement is very small indeed. In the average water-closet there is little chance of escaping contamination, occult or gross, on hands or body. Among those handling food and beverages, such as cooks, waiters and waitresses, bartenders, provision dealers, fruit dealers and peddlers, butchers, candy makers and dealers, milk peddlers, soda water clerks, delicatessen men and Pullman porters, it is exceptional to find one appreciating and practicing those principles of personal hygiene so necessary to prevent fecal contamination of the articles handled by them. In the light of the above it is easily perceived that the route of infectious microörganisms from the intestines, mouth, or nose of incipient cases, convalescents, and carriers into the systems of well persons is not circuitous. Many times in the course of the day's routine cleanly, healthy persons shake the hands of those infected or contaminated, grasp the contaminated trolley strap or door-knob, or pull the filth-laden water-closet chain, contaminating their own hands and frequently rendering the passage *via ora* of infectious material into their system swift and sure. The diseases most prominently identified with contact infection are the venereal diseases, generally by direct contact; the exanthemata, especially measles, scarlet fever and smallpox; diphtheria; mumps; the fecal-borne diseases, cholera, dysentery, especially the bacillary variety; typhoid; tuberculosis, and infestations with the metazoal parasites.

Infection by Carriers. It has always been held by physicians and the laity that healthy persons may transmit disease from the sick to the well, and until recent years it was assumed that the infection was borne by the hair, clothing, or hands, in the sense now understood as either indirect contact infection or infection by fomites. It is now known, however, that infections contracted from well or apparently well persons are generally received from subjects known as carriers, who may be defined as persons in or on whose bodies pathogenic organisms live and in most cases multiply, but who show no signs of the disease. For practical purposes under the heading of carriers will be included missed, unrecognized, mild cases and "contacts," or those who have become infected but who have not developed symptoms of the disease, and of whom many of the latter are in the incubation period of a frank attack. Unrecognized and atypical cases of the communicable diseases are much more common than was formerly suspected, and in some diseases doubtless exceed in number the recognized cases.

Carriers of bacteria are called "bacillus carriers," though pathogenic cocci are similarly borne. Those who carry protozoa are called "protozoan carriers." Carriers are further classified as "acute," "chronic," and "temporary." One who continues to discharge the specific organism some weeks after convalescence is an "acute carrier," while one who continues infected for months or years is a "chronic carrier." A "temporary carrier" is a person who for a short time only carries and discharges pathogenic microörganisms, but whose health is not impaired by their presence. Any of the foregoing may discharge the specific organism intermittently.

The data on the subject are as yet meager, but it is apparent that the number of carriers varies considerably in different diseases, probably being greatest in pneumonia and influenza in temperate climates, and in malaria and "sleeping sickness" in tropical regions, where the latter are endemic. Cerebrospinal meningitis carriers greatly exceed in number the cases, and it will possibly be shown that the same holds good for anterior poliomyelitis. It is estimated that diphtheria carriers equal about 1 per cent. of the population, but this is greatly increased during epidemics. The most reliable figures seem to show that about 3 per cent. of typhoid cases become carriers. The number of typhoid carriers among the populace at large is manifestly larger than this computation would indicate, as most of the instances of undiagnosed typhoid, contacts, and many intermittent carriers are not embraced in those figures. Human and rat carriers of plague no doubt exist, but apparently not in great numbers.

Study of the data available tends to show that the least contagious diseases, as pneumonia and cerebrospinal meningitis, have the most carriers, and that some of the most contagious diseases, as measles and smallpox, have few if any true carriers.

The germs harbored by carriers in some instances lack virulence, but animal experiments and laboratory accidents show that they may carry exceedingly virulent strains. Thus it is obvious that all carriers are not infectious, and doubtless many carriers are dangerous at times and innocuous at other times.

Infection from carriers is received in the same manner as from frank cases, by direct and indirect contact, the infection of food, etc., but the source of the infection is manifestly more difficult to trace, as they manifest no clinical symptoms, and laboratory diagnosis is necessary. The evidence is conclusive that many outbreaks in institutions and families have been caused by healthy carriers and mild, unrecognized cases; in some well-marked instances by infecting the food and in others by contact infection. The appearance of another disease in a hospital ward is usually due to the presence or visit of a previously undiscovered case of this kind and the dissemination of the disease by contact infection. The knowledge of these unrecognized foci of infection in human beings and of their almost countless opportunities for contact infection explains many and heretofore little-understood phenomena.

In the epidemiology of the fecal-borne diseases, especially typhoid, cholera, and dysentery, the subject of carriers holds an important position. When the gall-bladder is infected with typhoid bacilli the latter are frequently found in the feces. A number of these cases have ceased discharging the infectious organisms after operative procedures on the biliary passages, those not responding to surgical treatment probably having hepatic infections. The bacilli generally disappear from the majority of cases, but a few become chronic carriers, and are a serious menace to the health of all with whom they are in contact. Some have been shown bacteriologically to harbor the infection for long periods of time. Carriers of fecal-borne diseases have fewer organisms in their feces than frank cases, but they come in contact with more people, and as no disinfection is ordinarily practiced, they are a grave danger to their fellows.

The urine of about 23 per cent. of typhoid convalescents contains the typhoid bacilli, showing persistent infection of the urinary tract.

A still greater danger are those carriers who have never had the disease, or at least in whom it has never been recognized, they possibly having had mild or atypical attacks, improperly diagnosed. Contacts have caused a number of epidemics in institutions.

Many well-authenticated cases of infection of milk by typhoid carriers have been reported. The case of "Typhoid Mary" demonstrates the great danger of food infection by carriers, this now celebrated cook having infected twenty-six persons in six families in five localities in three States in five years before she was placed in isolation in a contagious disease hospital.

Mild, unrecognized cases of typhoid are much more common than was supposed before the recent introduction of improved diagnostic methods, and doubtless serve as foci of infection for more serious cases. Bacilli in the feces of those passing through the incubation period of the disease are a source of danger. No doubt some of the regiments, especially in the Volunteer Army, that suffered so severely from the epidemic in the camps during the Spanish War, were infected by recruits who were carriers during incubation. Contact infection soon disseminated the disease,' particularly among tent-mates and men in the same squads and companies.

Cholera convalescents do not carry the spirilla as long as typhoid cases carry the bacilli. There have been instances of spirilla being carried for six months, but they generally disappear a few days after recovery, the chief danger from cholera carriers being infection by contact, direct or indirect, with those in the incubation period and with mild and atypical cases contacts and healthy carriers. There are many cases of this disease that can only be recognized bacteriologically. In view of the almost exclusively non-saprophytic existence of the cholera spirilla, many epidemics and most sporadic cases can be accounted for only by attributing them to carriers. In the epidemics in the Philippine Islands carriers frequently transferred the infection from village to village, the filthy habits of the natives making ideal conditions for contact infection; they, also, by retaining the spirilla in a latent condition, caused the local outbreaks occurring at intervals. The detection of carriers among immigrants at quarantine by laboratory methods helped prevent the threatened introduction of cholera into the United States during its prevalence in Southern Europe.

All types of the bacillus of dysentery have been found in carriers. *Entameba histolytica* occurs in the feces before the development of the disease and for long periods after convalescence.

There are long latent periods during infection with *Piroplasma bigeminum,* causing Texas cattle fever; *Trypanosoma brucei,* causing nagana in cattle, and *Trypanosoma equiper-*

dum, the cause of dourine in horses. In the latter the organism remains latent in the sexual organs of the horse.

The pathogenic protozoa reproduce themselves asexually in the bodies of men and animals during these long periods of latency.

The arousing of old and unsuspected malarial infections by other infections or operative procedures is familiar to all clinicians. The disease is carried into uninfected districts by healthy carriers. In many parts of the tropics the adult population have had acquired immunity from infancy, due to this latent infection, which also causes the malarial attacks in new arrivals.

Yellow fever is transmitted and epidemics started by very mild and atypical cases, especially in children. As the virus is unknown, it is impossible in many cases to make the diagnosis.

In parts of tropical Africa, especially Uganda, the number of carriers of "sleeping sickness" approximates 50 per cent. of the population. The big game also act as reservoirs of the disease.

Filariasis is another tropical disease in which the infection is frequently latent, but which is transmitted, nevertheless, to well persons by the mosquito. In relapsing fever the blood is infectious to laboratory animals during the afebrile period and during convalescence.

The spirochete of syphilis has been reported to have remained latent in gumma for some years.

From analogy we are justified in assuming that there are human carriers of acute anterior poliomyelitis. Experiments have demonstrated the presence of the virus on the nasopharyngeal mucous membrane of monkeys. Later research will possibly show that carriers and atypical cases equal, if they do not exceed in number, typical cases.

The discovery of carriers, especially contacts, has cleared away much of the mystery surrounding the mode of extension of cerebrospinal meningitis. Doubtless the meningococcus borne in the noses of carriers is the chief source of infection. The meningitis develops only a small percentage of the cases infected. The microörganism causes few if any symptoms when confined to the nose, but severe symptoms immediately follow its invasion of the meninges. The same is true of infection with the pneumococcus.

The pneumococcus occurs frequently in the saliva of normal mouths, but these are apparently less virulent for laboratory animals than those from the sputum of pneumonia cases. The spread of influenza by mild and atypical cases, healthy carriers, and convalescents is a well-established fact.

There are many mild types of diphtheria that are never recognized. Healthy carriers, convalescent carriers, unrecognized cases, and contacts are greater in number than clinically diagnosed.

The tubercle bacillus is sometimes found on the mucous membrane of the mouth, throat, and nose. It is doubtful if it multiplies in those localities. Autopsies show that the bacilli frequently invade the tissues and remain latent for long periods of time, being found in glands that have undergone calcareous degeneration.

The lepra bacillus remains in a latent state in the nose, possibly for months or years.

There are mild and chronic cases of plague among rats. In the glandular type, without suppuration, the danger is *nil,* but late suppuration may release the bacilli. The dead bodies of rat carriers may infect other animals and man. The bacilli have been found in the sputum of convalescents from the pneumonic type of plague.

The bacteria of suppuration are normal inhabitants of the skin and mucous surfaces, which no doubt gain admission to the body from time to time, remain latent for varying periods, are carried to distant organs, and cause suppuration as the result of traumatism.

The spores of the tetanus bacillus may be injected into the body and remain latent. Surgical operations or traumatism may later favor their development, thus explaining some cases of tetanus after wounds, surgical or accidental.

The gonococcus is often found in cases long considered cured, their persistence for ten years or more having been reported. In women they become encysted in the tubes and ovaries. In mild and chronic cases of gonorrhea it is very difficult to demonstrate the germ. Latency is the cause of many cases of innocent marital infections and makes medical supervision of prostitution very difficult.

There are probably no chronic carriers of smallpox. ''Variola sine eruptione'' and extremely mild cases of varioloid transmit the disease and may cause malignant cases.

True carriers of measles probably do not exist, the disease being transmitted by typical cases during the early catarrhal stage before it is possible to recognize it.

Infection by Insects. Insects as carriers of the virus of communicable diseases had been under suspicion for some years, but were first definitely incriminated by Theobald Smith in 1893, in the case of the tick and Texas fever of cattle. Other great names associated with this work are Manson, Ross, Grassi, and Finlay, and the United States Army Yellow Fever Commission, Reed, Carroll, Lazear, and Agramonte. The importance of this phase of epidemiology is constantly growing.

The two modes of transmission of disease by insects are the biological and the mechanical. In biological transmission the virus is probably always a protozoan having part of its developmental cycle in the insect, which phase of its life is known as the extrinsic period of incubation. Infection conveyed without a developmental cycle or period of incubation in the insect is known as mechanical transmission, and is practically limited to disease caused by bacteria.

The insect may be the intermediate host, in which case the asexual phase of the life cycle takes place in the insect, or the definite host, in which case the sexual phase occurs in the insect.

The virus may be conveyed mechanically by insects in a number of ways: The body, legs, wings, etc., may be grossly contaminated with material containing the infectious organisms, the insect alighting on food, hands, lips, etc., thus easily transmitting the disease; the germs may be carried by the proboscis only of a biting or stinging mosquito, in which case the inoculation resembles an injection with a hypodermic syringe; the virus may be contained in the excrement or body of the insect, and be rubbed into the wound made by the bite or sting, possibly at the time the insect is killed.

In the biological transfer of disease each species or genus of insect carries a specific disease. Malaria is transmitted only by anopheles mosquitoes and "sleeping sickness" by the fly, *Glossina palpalis*. The virus is at times transmitted to the next generation of insects by heredity. The same family of insects conveys different types of virus: mosquitoes transmit protozoa, the filterable virus of yellow fever and filaria; flies carry bacteria, protozoa, and the ova of metazoal parasites.

Insect-borne diseases are as a rule confined to the immediate locality of the breeding places of the insects, which are not of themselves great travelers. They are transferred as parasites of man and the higher animals from one country to another and also in conveyances, land and maritime—it is man that carries the infection as a rule. The area of distribution of disease rarely coincides with the geographical distribution of the specific insect, being much more limited in extent. When epidemics of insect-borne diseases occur the insect host is always found in enormous numbers.

Infection by Water. During the latter half of the nineteenth century a number of epidemics of fecal-borne diseases were clearly traced to infected water supplies, a fact that led the profession to assign undue importance to water as a vehicle for the transmission of communicable diseases. It was not only credited with being the chief mode of infection in typhoid fever and cholera, but was supposed to transmit malaria and yellow fever as well as other diseases. Advanced scientific methods in the study of the living causes of disease and the discovery of human and insect carriers have modified the former deductions and radically changed the latter ones.

The micro-organisms of the fecal-borne diseases have only a short saprophytic existence and feeble resistance. No pathogens multiply to any great extent in potable water, as they soon die from lack of nourishment, pure water containing little organic matter, while the action of sunlight and the antagonisms of many harmless saprophytes aid in their elimination. Water is, of course, in many cases used before these agencies have time to purify it. After infection water may pass through the earth for considerable distances, the natural filtering properties of the soil resulting in a decrease of the number of bacteria.

Disease is transmitted by water under the following conditions: (1) By its use as a beverage; (2) by using it for cleansing clothes, utensils, and food; (3) by introducing it into the tissues through wounds or by instruments, such as a hypodermic syringe; (4) through bathing.

The diseases disseminated by drinking water are typhoid fever, cholera, dysentery, the diarrheal group, and some of the parasitic worms.

Water-borne outbreaks of typhoid are, as a rule, brief in duration and explosive in character. Careful inspection of the supply has in many cases shown contamination, a short time before the outbreak, by the feces and urine of typhoid cases. It is seldom that the bacilli are found in the infected water. Conclusions as to the source of the infection when municipal water supplies are involved are arrived at only by careful comparison of the typhoid statistics of neighboring communities using different water supplies. The pollution of municipal supplies may be due to overflow of privies, or the placing of the discharges of typhoid cases on the ground, where they may be washed into the streams, especially in the spring, during freshets. The cities on the Great Lakes have suffered at times through the wind blowing sewage into the intakes of waterworks, and by dredges dumping infected mud near the intakes. Cities drawing their water supplies from streams or lakes that receive large amounts of sewage generally have a high death rate from typhoid. The relation between clean water and high typhoid death rate is shown by the marked decline of the latter following improved water supplies in many eastern American and European cities.

Polluted wells at times are sources of infection, especially in rural districts. They generally become contaminated by typhoid discharges thrown on the ground in the immediate vicinity. There are a few recorded cases of outbreaks from befouled springs.

There have been many severe outbreaks of cholera due to contaminated water supplies, the most celebrated one being the epidemic at Hamburg in 1892. The life of the spirillum in water is quite short. No doubt the disease is kept alive by contact infection after being started by impure water. It is difficult to determine the relative importance of the latter in the dissemination of cholera, but at times it is vital.

In the Far East and in the tropics bacillary dysentery is frequently a water-borne disease. Well water and river water become polluted through the filthy habits of the natives, the washing of clothes near the wells and in the streams, and the contamination of the streams by drainage from fields where human feces has been used as fertilizer.

All we are able to deduce from the data now available regarding the relation of impure water to the diarrheal group is that it is a source of diarrhea and at times a rather serious one. A fall in the death rate from diarrheal diseases has followed improvement in the water supply, but so many factors

—such as general sanitary improvement, better care and feeding of infants, etc.—are involved in the subject that definite conclusions are impossible.

Fruit and vegetables washed with polluted water may become infected with the fecal-borne diseases, including the ova of parasitic worms, this being notably true in the Far East, where human excrement is used so commonly as fertilizer. Cooking and table utensils may be contaminated in the same way. Milk diluted with polluted water or contained in receptacles washed with the water may be rendered impure, and is a source of serious danger, as milk is an ideal culture medium for germs. This method of infection of milk is probably more frequent than that derived *via* the milk from the cow.

Washerwomen may be infected when foamy particles are thrown into the air and alight on the face or in the mouth or nostrils, as there is some evidence that diphtheria and typhoid fever have been transmitted in this way.

Most waters carry comparatively few virulent pyogenic organisms. Infection during operations is most to be feared from utensils, hands, dressings, and suture materials, though muddy water may contain the virulent organisms found in earth, the bacillus of tetanus, and the bacillus of malignant edema or their spores.

Puerperal sepsis has been caused by intrauterine douches of solutions of germicides too weak to sterilize the water. Infection *via ora* may occur in public baths, swimming pools, and tanks.

In bathing, the water may be swallowed, or may enter openings of the body and cause various acute inflammations of the mucous membranes, including conjunctivitis, rhinitis, pharyngitis, and laryngitis. The pus-forming bacteria and the colon bacillus are frequently found in the water of public bathing tanks and pools, but there is little, if any, positive evidence that the venereal diseases are ever transmitted in this way.

Infection *via* the skin by parasites which penetrate it and find their way into the deeper tissues and blood may occur while bathing. Such are the *Uncinaria duodenalis* and the Guinea worm. The danger of transmission of the communicable diseases by ice has little more than a theoretical foundation, but a few well-authenticated cases of typhoid from this source have been reported.

Infection by Food. Milk heads the list of foods that cause human morbidity for the following reasons: It is an excellent culture medium for bacteria; it is generally consumed uncooked; its keeping qualities are poor, and it is easily contaminated during handling and transportation.

It is credited with conveying the following diseases: Typhoid fever, scarlet fever, diphtheria, septic sore throat, tuberculosis, Malta fever, foot and mouth disease, milk-sickness, the diarrheal group, and dysenteric diseases. The indictment is strongest against typhoid fever, scarlet fever, diphtheria, and Malta fever.

The milk may be defiled by diseased cows, as in foot and mouth disease and bovine tuberculosis, or by infected goats in the case of Malta fever. The infection is, however, much more common from human sources, and may occur at the farm or dairy during transportation, or at the place where the milk is ultimately consumed. The milk may be diluted with infected water, or the bottles or utensils may be washed with the latter. It is contaminated frequently by carriers and other infected persons during milking or handling and caring for the pails, bottles, strainers, etc. Disease has been transmitted by carriers or convalescents tasting the milk, and at times by flies.

Milk-borne outbreaks of typhoid fever, scarlet fever, and diphtheria have an explosive character, resembling water-borne outbreaks of typhoid. When a large number of cases of typhoid occur among people drawing from the same supply, within a few days, in a community with an average typhoid rate, it is presumed to be a milk-borne outbreak. Such manifestations are more apt to occur among the children of prosperous families, they being the greatest milk consumers. Many times this source of infection has been proved bacteriologically. Milk transmits typhoid more frequently than any other disease.

Scarlet fever epidemics are more rare than typhoid, and the infection is practically always from human agencies.

Milk is generally infected with diphtheria by carriers or cases. There are authentic reports of infection on cows' teats with diphtheria, but these cases are rare.

In septic sore throat the contamination of the milk with virulent streptococci is generally from human sources, but diseased udders may account for some outbreaks.

Milk is infected with tuberculosis by the diseased udders of cows and by pollution with feces of cattle containing the bacilli—many of the cases in children under five years being of the bovine class, the infection being derived in large measure from cows' milk. Much of the milk used in America and Europe contains the tubercle bacillus in sufficient numbers to infect laboratory animals. The danger seems, in the past, to have been overestimated, though doubtless many deaths are due to this cause. In parts of the world where little if any cows' milk is used tuberculosis prevails extensively in the forms generally credited to milk infection.

Malta fever is generally contracted by drinking the uncooked milk of infected goats, in which the cocci continue to be discharged for a time after convalescence.

Foot and mouth disease is transmitted to man by the consumption of raw milk and milk products from infected cattle, as is milk-sickness, a disease of cattle formerly seen in the Central West.

The various microörganisms causing the diarrheal group of diseases grow in milk, and cause great morbidity and mortality in summer, especially among infants in crowded cities. Contact infection no doubt accounts for many cases formerly attributed to milk.

Infection by meat is due to the following general causes: Animal parasites, including tape-worms and trichinæ; putrefactive bacteria with which the carcass becomes infected after slaughter; infection during the life of the animal by members of the colon group, including *Bacillus paratyphosus, Bacillus enteritidis,* and *Bacillus morbificans;* infection during life by the *Bacillus tuberculosis* and other pathogens.

The animal parasites transmitted to man by eating infected meat are: *Trichinella spiralis*—causing the disease known as trichiniasis—and *Tænia solium,* from pork; *Tænia saginata,* or *mediocancellata,* from beef; *Dibothriocephalus latus,* from fish. Trichiniasis is by far the most important disease contracted through eating infected meat.

The disorders due to putrefactive bacteria which infect meat after slaughter are not in a strict sense communicable diseases. They resemble metallic or other chemical poisoning.

The colon group probably occurs in the bodies of healthy animals, carriers and convalescents, as well as in the bodies of diseased ones. The toxins of these bacteria are not always destroyed by heat, hence severe gastro-intestinal disturbances have occurred after eating infected meat that has been cooked.

It has been assumed by the medical profession and the laity that tuberculosis is transmitted by infected meat. This seldom, if ever, occurs, for the reasons that the bacilli do not as a rule inhabit the muscles or fat—the parts most frequently eaten—and as they are easily killed by heat, cooking would eliminate them; the use of meat is increasing while tuberculosis is decreasing.

Many outbreaks of typhoid fever have been traced to oysters, clams, and mussels from sewage-polluted beds. A certain amount of "residual" typhoid in American and British cities has been attributed to this cause.

Infection by Fomites. The distinction between indirect contact infection and infection by fomites is necessarily rather arbitrary and indefinite. Infected drinking cups, closet-seats, fingers, pipes, etc., are media for the transfer of fresh infective material from one person to another. Fomites are objects carrying infective material of a strength sufficient to cause other cases of the disease for at least some days, and possibly months or years. Examples of the latter are the spores of tetanus carried on blank cartridges, causing the disease many months after the infection of the cartridges, and the transference of the virus of smallpox from one town to another through infected books.

The theory of the transmission of communicable diseases by fomites is a very old one, but recent accurate investigation has produced very little scientific evidence to uphold it, though even to this day it offers and is welcomed as a plausible explanation for epidemics of disease whose origin cannot be determined. Clothing and other textile fabrics are commonly held to be agents most likely to transmit disease, but it is now known that only in very rare instances does this occur, a rather gross infection of clothing being generally required to transmit in this manner. The occasional droplet infection of physicians' and nurses' clothing by oral and nasal discharges from tuberculosis and diphtheria patients is of minimum danger, as the microörganisms of those diseases soon lose their virulence on exposure to air and sunlight. Doubtless much infected clothing from patients and carriers goes to laundries in an unsterilized condition, but only a very few of the alleged instances of the transmission of typhoid in this way have borne the scrutiny of careful scientific investigation. The added factors of susceptible age, overwork, and poverty common among laundry workers would more than account for any apparent excessive prevalence of tuberculosis among this class.

It was an expensive assumption that yellow fever was transmitted by fomites. The discovery that the louse transmits typhus removes that dread disease from the category of fomites-borne infections. In times past many outbreaks of smallpox were attributed to domestic and imported rags, though scientific proof was almost invariably lacking, as in only a few instances were the cases in towns where smallpox was not already prevalent. Alleged instances of infection due to clothing laid away for months or years have in many cases been proven to be due to infection by personal contact. It is persons, not things, that in the majority of cases transmit disease. The simple fact that a case or cases of a certain disease follow the arrival of textile or any other kind of possible fomites in a given locality from a region where the disease is known to prevail is in itself most unsatisfactory evidence of its transference in this manner; to be convincing it must be supported by such additional proof as microscopy is able to adduce.

The increase of diphtheria and scarlatina noted occasionally at the commencement of school terms has been attributed to infection by fomites, the assumption being that the disease was brought by infected clothing of scholars from homes where the diseases were present. This spread of the infections is now shown to be due to carriers among the children themselves.

Much praiseworthy effort has been expended in the search for pathogenic bacteria on fomites, but with the exception of the sporulating bacilli, anthrax and tetanus and the germs of suppuration, this has borne very little fruit. The life of bacteria on fomites is controlled by such factors as dryness or moisture, presence or absence of sunlight, amount of nutriment, etc. When we consider that only under the most favorable circumstances do most of the pathogens maintain a saprophytic existence, it is manifest that their life on such articles as textile fabrics, books, toys, etc., is short and precarious. The bacilli of anthrax and tetanus and the pus-forming microörganisms undoubtedly develop to a limited extent in the soil, but the growth is far from luxuriant or common. The bacillus of diphtheria has an insignificant saprophytic existence at times in milk. The bacteria of typhoid, cholera, dysentery, and plague, under unusual conditions, develop as saprophytes. There is not the slightest evidence that the organisms of gonorrhea, syphilis, malaria, "sleeping sickness," tuberculosis, pneumonia, influenza, cerebrospinal meningitis, typhus, whooping cough, or the viruses of smallpox, yellow fever, or scarlatina ever lead anything but a parasitic life.

The germs of suppuration are the intimate and constant associates of the human race, and can be found on anything that has been in contact with man. Pus infection by fomites is the most perfect example of that mode of disease transference. While the microörganisms multiply only to a limited degree under saprophytic conditions, their ability to resist the influence of drying enables them to live on such fomites as floors, woodwork, clothing, books, money, and utensils and instruments of various kinds.

Virulent diphtheria bacilli have been frequently found on bed-clothing, handkerchiefs, and towels used by diphtheria patients. More rarely they are found on drinking glasses, dishes, and other utensils. In swabbings from the latter class of fomites, as well as from rooms occupied by diphtheria cases, the percentage of positive results is small. Research apparently shows that the bacilli are by no means plentiful even on objects that have been in intimate contact with cases.

With the exception of the microörganisms of pus, the tubercle bacillus has been found outside the body more frequently than any other pathogen, but its power to resist drying has been overestimated. In damp masses of sputum some of the bacilli survive for months, and have been found on floors, library books, furniture, etc. Instances have been reported of virulent bacilli being found on clinical history charts of tuberculosis cases, and on books that have been put away, presumably in darkness, for years.

The life of the cholera spirillum outside the body is short. It is noted that the reports of the organisms being found on the effects of patients came from the early observers, whose laboratory methods were not accurate.

The spores of tetanus are examples of one of the most resistant forms of life; they have been known to exist in a virulent state on such fomites as splinters of wood for over ten years.

Typhoid bacilli, when thoroughly dried and exposed to light, live only a few hours or days. In such media as slightly moist feces, protected from the light, as in cases where contaminated bedding and clothing are packed away without being sterilized or laundered, they may retain their virulence for some months.

The micrococcus of Malta fever offers about the same resistance to drying and light as the typhoid bacillus.

The bacillus of dysentery seems to possess more resistance to drying than the typhoid bacillus, but very quickly succumbs to light.

Cholera spirilla have very little resistance to drying, and survive at most only a few days in dry feces, though they have been known to live six or seven months in damp feces.

The diphtheria bacillus at times resists drying for some weeks, but this appears to be largely of academic interest.

Fomites infection is not entitled to the importance once assigned to it.

Infection by Air. From the clinical and laboratory evidence now available it appears that infection by air has been given undue prominence in epidemiology. This is not surprising, as the viruses of the communicable diseases were considered to be gaseous and therefore diffusible. It was assumed that this invisible poison was carried by air currents and winds, that it was contained in the breath and other emanations from the body, and that it arose from moist soil and filth. The existence of carriers being unsuspected and the importance of mild and atypical cases not being appreciated, the origin of cases that had no apparent connection with previous ones was readily explained as being caused by deadly effluvia. The development of knowledge of the biological origin of disease and the later discovery of insect and human carriers have relegated aerial infection to a minor rôle, though at the same time it is impossible to state with any degree of precision the importance that should be attached to infection by air. If it does take place frequently, as believed by the laity, it is a source of danger hard to avoid, and makes proper education in regard to personal cleanliness and contact infection very difficult. Positive information on the subject is still scanty, and it would be well to consider this phase of the dissemination of communicable diseases with an open mind.

It is impossible to convey microörganisms by gas, because in order to transmit infection the air must contain particles of a liquid mist or a dust on which the biological agents are transported. Exceptionally violent winds may convey distinct particles of water with bacteria enclosed. It was formerly taught that sewer air was contaminated by particles of liquid containing bacteria being thrown into the atmosphere by the rupture of bubbles, but as gravity soon brings these particles back to the surface of the water or ground, they cannot be a factor of any moment in the transmission of disease.

Grains of dust contain a great variety of microörganisms, but while these consist almost entirely of molds, yeasts, and harmless saprophytic cocci, the carriage by dust of the germs of tuberculosis, suppuration, diphtheria, dysentery, typhoid fever, and Malta fever has been demonstrated bacteriologically. The same possibility exists in regard to plague and the spores of anthrax, but the danger from this method of transmission is very slight.

The moist particles that are ejected by men and animals in coughing, sneezing, and speaking are temporarily suspended in the air for a few feet around the subject, but rapidly subside by gravitation. Infection in this manner no doubt occurs in tuberculosis, diphtheria, measles, scarlet fever, the pneumonic form of plague, influenza, and pneumonia, and is known as "droplet infection"—really a phase of direct contact infection, and is the chief method of aërial infection.

There is some slight evidence of the transmission of smallpox by aërial infection from hospitals, but in few if any cases has it been shown that there was not at least a chance of contact infection.

If scarlet fever and diphtheria were air-borne, they would spread more readily among families and in tenement houses.

There is some bacteriological evidence that typhoid is spread by infected dust from dried discharges, and this may be true also of cholera, dysentery, and infantile diarrhea. In some of the reported incidences the possibility of fly-borne infection could not be eliminated. The fecal-borne diseases are certainly never transmitted by air in well-managed hospitals, and never to any great distance, the bacilli being soon killed by air and sunlight.

It was formerly assumed that influenza was borne great distances through the air. It is now known that while it does spread by droplet infection, carriers and contact infection are the chief modes of its dissemination.

The success of medical asepsis in French and English hospitals shows that while it is spray- or droplet-borne, contact is the usual method of transmission of measles. The general atmosphere of the room or ward does not become contaminated.

There is some slight evidence tending to show that the atmosphere of the room may be infected by pneumonic plague cases, while the danger of infection by droplets is very great.

Modern aseptic surgery shows the possibility but not the probability of infection by air. In operative procedures infection by contact is the only mode considered.

Chapter IV

GENERAL PROPHYLAXIS

Protection against the communicable diseases has in times past been a function of the medical profession, with some assistance from the priesthood. Modern prophylaxis requires the coöperation of the entire population, and has become a part of the science of sociology. Dissemination of a knowledge of the nature and modes of transference of the transmissible diseases is necessary to prepare the laity for these new duties. That the campaign of education is now on in full force, and is attracting widespread attention, is shown by articles couched in non-technical terms treating of public health and personal hygiene becoming prominent and popular features in the periodical press.

There are many means available by which the propaganda may be carried on. The public and private schools afford a fertile field, especially if the teachers are properly instructed in their duties, which unfortunately, is far from being generally the case. Public playgrounds and recreation centers are suitable places for instruction in personal hygiene as well as for physical exercise. Many children and some adults may be reached through this channel.

The newspapers are used by health officers and boards of health, especially in times of epidemics, to spread information regarding the public health. Weekly and monthly pamphlets are issued by many boards of health, municipal, county and State, for the information and instruction of the people. Some of the life insurance companies and the fraternal organizations having insurance features issue circular letters and pamphlets of real value bearing on the preservation of health. Public lectures, preferably illustrated, on health topics, given under the supervision of county medical societies, women's clubs, etc., spread much valuable knowledge.

Public welfare clubs, if they include such responsible citizens as some of the medical profession and clergy, should be a strong factor in the work. Special clubs, mothers' meetings, and the various organizations that foregather at parish houses under the direction of the clergy and lay workers, with the coöperation of physicians and nurses, are spreading much useful information. Courses of lectures on the social diseases, the value of antitoxins, personal hygiene, and local sanitary conditions are there given to advantage.

The work of medical and sanitary inspectors and visiting and school nurses is bearing fruit. Tuberculosis dispensaries and social and university settlement centers are now a factor in the cause.

The Public Health Education Committee of the American Medical Association, the Board of Public Instruction in Medical Matters, and the Life Extension Institute are planning and guiding the work of implanting the idea that, in a sanitary and hygienic sense, a man *is* his brother's keeper.

The statement of Pasteur that "It is within the power of man to rid himself of every parasitic disease" is only theoretically true. The lifetime of some generations must pass before this idea is even approximately realized, but every generation will see a marked advance. Preventive medicine is so blended with sociology and the great, broad problems of human betterment, that its progress must go hand in hand with the material improvement of the species and its surroundings, habits, manners, and customs.

Many of the problems of prophylaxis have been solved theoretically and practically, others only theoretically. In this chapter the writer attempts in a general way to describe the means now available for successful combat with the communicable diseases. The minute details of disinfection, quarantine, personal hygiene, etc., are presented in separate sections, and all theoretical and academic discussion is avoided.

Modern prophylactic measures are based upon a thorough understanding of the modes of transmission of infection and a knowledge of the stage of a given disease that presents the greatest danger. For practical purposes a knowledge of the sources and modes of infection is of greater importance than a knowledge of the cause. The meningococcus has been known for years, but the prophylaxis of cerebrospinal meningitis is far from satisfactory, while the cause of yellow fever is unknown, though the disease is perfectly controlled.

In view of the foregoing, the preventive measures will be described under the same headings as the dissemination of the communicable diseases, viz.: (1) Contact; (2) carriers, etc.; (3) insects and other vermin; (4) water; (5) food; (6) fomites; (7) air.

Contact. It is now recognized that contact is the chief mode of infection. Formerly dependence was placed on the authorities, lay and medical, to protect the well from the sick, but it is now apparent that successful defense against infection is much more a personal affair, and individuals can and must protect themselves. Appreciation of the grave danger from carriers has accentuated the importance of personal effort in prophylaxis.

The principal danger is from contact with carriers, unrecognized cases, etc.; in other words, occult contamination. After a communicable disease is once under observation there is little danger for cleanly, intelligent people. Contact infection can be avoided only by the practice of personal cleanliness and hygiene—the more cleanly, refined, and decent the people become the less the danger. With correct habits the danger is not great for adults, but children have a natural tendency to flock together, to put things in their mouths, and to get dirty, hence the rapid spread of disease among them.

It is neither expensive nor troublesome to be decently clean, and it is as important in family life as in schools, hospitals, and all institutions where human association is close and constant. If people practiced reasonable cleanliness and put nothing in their mouths except what belonged there most communicable diseases would be avoided.

The only way to prevent contact infection from recognized cases is by rigid adherence to the precepts of medical asepsis and bedside disinfection as described under "Disinfection and Disinfectants." These have been grossly neglected and misunderstood by physicians and nurses; a clearer comprehension is most essential. Too much faith has been placed in room disinfection; we have not been striking near enough to the sources of infection.

The most important detail in the care of patients is the prompt destruction or disinfection of infected discharges and material, including articles used about the patient. Constant cleanliness is of vital importance. Infected matter, especially on hands and bodies, must be removed as well as disinfected. Soap and water penetrate and remove viscid discharges and make possible the action of chemical disinfectants. It is more important to remove than to treat dirt and filth, whether on human bodies, on linen, or in the sick room, kitchen, factory, school, or public conveyance. The public and part of the medical profession overestimate the value of germicides—a wrong impression which masks the value of cleanliness. Frequently dependence is placed, necessarily or otherwise, on chemical solutions for bedside disinfection. This is satisfactory if properly carried out, but the treatment of infected discharges, feces, etc., is apt to be defective, and an infected receptacle, which is a source of danger, is left.

No disinfectant is so effective, cheap, or available as boiling water. The sick-room or an adjoining apartment should have a stove of some kind to heat the water for the disinfection of all infected material and articles, the boiler or other receptacle of which should be large enough to hold the bedpan. Handling bedpans not immediately disinfected after the discharges have been removed for disinfection is a mode of infection. In hospitals the steam chamber may be used to advantage, especially for bed and body linen.

The value of medical asepsis in the prevention of contact infection is proven by the success attending the care of contagious cases in hospitals employing the cubicle system, in which the isolation is only constructive. The bed is enclosed by tape or cord and the same nurses attend contagious and non-contagious cases, but practice strict medical asepsis.

Carriers. This exceedingly difficult and complex problem in preventive medicine is hardly even theoretically solved. No practical solution is in sight, as people cannot be imprisoned for being infected. It is deeply involved with the subject of contact infection, as much of the latter is derived from carriers. As previously emphasized, the public must be taught the danger from carriers and the value of cleanliness. Known carriers must be instructed as to the danger of handling food intended for others, and prohibited, as far as possible, from so doing. Carriers and potential carriers must be placed in isolation, in a constructive sense, by the practice of strict personal hygiene. This applies to themselves and to those with whom they come in contact.

Using the term in its very broadest sense carriers may, for prophylactic purposes, be divided into three classes: (1) Typical carriers, those in the incubation period of disease; mild, unrecognized cases; contacts, etc. (2) Recognized cases of disease. (3) Convalescent carriers.

The detection of carriers of the first and third classes is one of the chief duties of the epidemiologist. Those of the second class can or should be recognized by their typical symptoms, but not all cases are seen by practicing physicians. These people are a grave potential danger, but, by reason of their known illness, more care is used in guarding against them.

If a person has been exposed to infection it may be assumed that he is infected. In the incubation period of typhoid fever and diphtheria he is infective and a source of danger. Scarlet fever and measles are not infective during the incubation period, but the prodromal stage, before the diseases can be diagnosed, is the period of greatest infectivity. After the development of typical symptoms or the detection of the germ by laboratory methods the existence of the previous danger period may be dismissed in typhoid and diphtheria, and the close associates of the patient during this period placed under observation. The most common method of recognizing typical carriers, e. g., persons harboring and distributing infectious microörganisms for indefinite periods without themselves exhibiting symptoms of the disease, is by definitely tracing the infection to a given carrier, many typhoid carriers having been located in this way. Under certain conditions systematic laboratory tests can be made of suspected persons and the specific germs actually found—a routine procedure in schools, hospitals, etc., when the presence of diphtheria carriers is suspected, and at quarantine stations in times of danger from cholera. It obviously cannot be done in many diseases of unknown origin.

Carriers are sometimes discovered by accident during tests made for other purposes, those of the first class remaining frequently undiscovered until they have infected some one. Contacts are very numerous, but their period of infectivity is short and they are poor distributors. The greatest danger is from the true or internal carrier.

Convalescent carriers may be discovered by the history of their attacks or by the existence of aftermath lesions such as desquamation, paralysis, etc. Blood reactions such as the Widal are of great value in this field. Cultures made from swabbings from the throat and nose and blood cultures confirm uncertain diagnoses and reveal possible carriers. Once discovered, the convalescent carrier should be kept under surveillance until all practical means have been exhausted to rid him of the infection. These failing, reliance must be placed on his adherence to careful instructions as to the care of himself so as to minimize the danger to others. Some diphtheria carriers yield to antitoxin treatment. Surgical procedures on the biliary tract have removed the infection in some typhoid carriers.

In tracing out carriers the starting points should be the known foci of infection, generally frank cases. From these the trails should be followed out into the zones of infection which surround them until carriers, whether contacts, those in the incubation period, convalescents, or true carriers are located and means taken to prevent their doing further damage.

Early diagnosis is of great importance in controlling foci of infection. Skilled diagnosticians are in the employ of the health departments of large cities, and are of great assistance in clearing up doubtful cases. The mails make laboratories, private and government, always available to verify clinical diagnoses.

Prompt reporting of communicable diseases is a feature of preventive medicine that has been seriously neglected in many States, the registration and control of an infectious focus being of much greater importance than the reporting of a death. The early and complete reporting of communicable diseases puts the health officer on the trail of the infection, so that it may be followed to its fountainhead.

Insects and Other Vermin. All the parasitic animals, especially the bloodsuckers, that live on man and the higher animals are potentially dangerous, and may act as transporters of germs. If they do not act as intermediate biological hosts they may transfer infections in a mechanical way, or the minute wounds made by their bites and stings may allow the entrance of such infections as erysipelas, pus, anthrax, tetanus, etc. New diseases may be established, as in the past the known diseases have possibly originated by the alliance of host, insect, and parasite.

The suppression and control of insect-borne diseases depend upon a thorough knowledge of the biology of insects, rats and other animals from whom man receives disease through insect carriers. Without this knowledge of the life history and habits of insects and other vermin, much time and money are lost and little or no results are achieved.

To be healthful, human habitations must be free from insects and other vermin, and to attain this freedom cleanliness should be exercised, particularly in kitchens, pantries, dining rooms, cellars, bathrooms, water-closets, back yards, etc., i. e., the places where food is kept or used, where moisture is present or rubbish likely to collect.

The breeding places of all classes of vermin must be destroyed or shielded from their visits. Floors and other surfaces must be kept free from organic dirt upon which vermin feed, and from cracks and crevices which collect dust and dirt and serve as breeding places. Food must be protected against insects, rats, and mice. Old cans, broken bottles, rubbish, garbage, and general untidiness seen about living quarters are a sure sign of infestation by vermin, insect and mammalia, as they afford breeding places, hiding places, and food for the undesirable guests.

Mosquitoes. A campaign against mosquitoes requires time, money, and the services of entomologists, engineers, and administrators as well as physicians qualified as sanitarians. Prophylaxis against mosquito-borne diseases must be devoted to human beings and to the specific species of mosquito involved in the disease confronted. Measures directed against anophelines would be useless against the domestic calopus that transmits yellow fever.

Preventive measures against mosquito-borne diseases may be studied under the following headings: (1) Medical prophylaxis. (2) Protection of human beings against the bites of mosquitoes. (3) Measures against breeding places. (4) Destruction of larvæ. (5) Destruction of the insects.

Medical Prophylaxis. The details of medical prophylaxis are described under malaria, as that is the only disease in which these measures are of value.

Protection against Mosquito Bites. Measures toward the protection of man against the bites of mosquitoes require his intelligent coöperation, and this, especially in the tropics, is very difficult to secure. Attempts to instruct the lower-class natives as to the importance of mosquito bites in causing serious illness is not productive of much good, but efforts should, nevertheless, be made by instruction in the schools, lectures in the vernacular, and demonstrations to impart some elementary knowledge of the matter. As the educated public of the tropics learn to appreciate the monetary loss caused to merchants, planters, governments, and other employers of labor by mosquito-borne diseases, their hearty assistance, financially and otherwise, will be secured.

The quarters for native employees should not be built in sheltered places, such as valleys, but on high ground, away from likely breeding places of anophelines. The better class of houses should be built away from the native quarters or town, as the native children are reservoirs for the malarial organism. Brush and much vegetation are undesirable, as they afford shelter for the insects.

The actual prevention of mosquito bites is effected by rendering habitations mosquito-proof, by the use of the mosquito net, and by the use of chemicals offensive to mosquitoes.

In screening a building careful attention must be paid to details. Brass or bronze screens of twenty or more meshes to the inch are the most efficient. Fabric screens are apt to pull out of shape, making some meshes larger than others, hence a fine mesh should be used. Iron screens require paint for

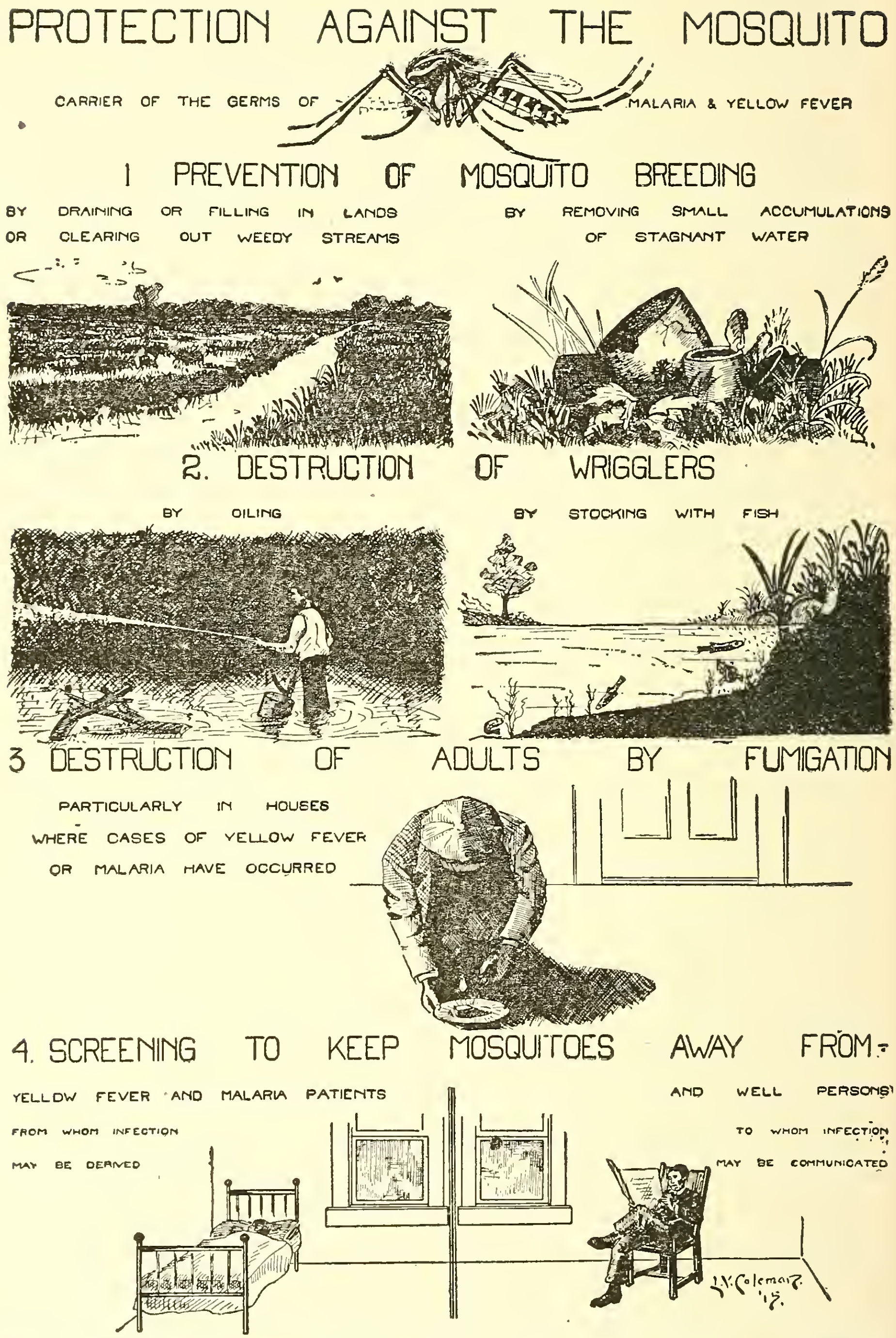


Fig. 17.—Chart Showing Mosquito Control Methods. (*American Museum of Natural History, New York.*)

preservation, thus interfering with ventilation. All parts of a building occupied should be screened. In the tropics the verandas or galleries may be screened instead of each separate window, with a resultant comfort in keeping out not alone mosquitoes, but all insects. Portable mosquito-proof rooms made of wooden framework and metal screen which may be erected inside a larger room or on a veranda are useful for engineers and others working in the tropics. Chimneys, ventilators, and other openings must be screened and all screens must be frequently inspected for holes and for general repair purposes. A screened vestibule, with the doors opening outward, is desirable. There should be no vegetation near the entrances, as it harbors mosquitoes.

The mosquito net or bar is absolutely essential in mosquito-infested regions. It should be strong and closely woven and kept in good repair, as if torn it becomes a mosquito trap. It should be kept clean, especially on top, preferably hung from the ceiling, and when in use it must be stretched tight and tucked under the mattress, never allowed to hang loose or rest on the floor. In the daytime the bottom should be twisted and gathered up to keep out mosquitoes. Persons visiting mosquito-ridden countries should carry their own mosquito nets, as those found in hotels or other resting places, houses, etc., are frequently not to be depended upon. Sentries, watchmen, and others who are compelled to be out at night in malarious districts or in the daytime in times of yellow fever epidemics should use a veil of mosquito netting suspended from the hat or helmet to the chest and shoulders. The hands and wrists should be protected by gauntlets and the ankles by leggins.

Certain volatile substances, including the oils of citronella, pennyroyal, and peppermint, spirits of camphor, lemon juice and vinegar, have a limited value in keeping mosquitoes away for a time. They may be rubbed on the face and hands, sprinkled on the pillow or on a towel hung over the head of the bed. Their power is expended before morning.

Measures against Breeding Places. The most effective procedure in an anti-mosquito campaign is the prevention of the multiplication of the mosquitoes by destruction of their breeding places. Communities and individuals working in unison secure the best results. Heads of households and estates increase their own security and serve as worthy examples to their neighbors by individual efforts in anti-mosquito work.

The eradication of the natural breeding places at times requires engineering skill. Small pools of water may be filled in with ashes and other harmless rubbish or with earth from some neighboring elevation, care being taken not to create thereby another breeding place by making too deep a hole where soil is borrowed. Marshy land bordering the sea, lakes, or rivers may be filled with silt or sand pumped from harbors or channels for that purpose or when the latter are being deepened. It is cheaper to drain swamps and ponds. In draining swamps, marshes and pools above the mean high tidal marks on seacoasts only the pools are drained—not the soil. The latter may also be eliminated by connecting them with tide water by ditching.

Marshes are drained by ditches having straight sides and of sufficient depth and fall to avoid stagnation. Ditches are prone to become choked and therefore require frequent inspection. Cultivation is a most effective way of disposing of small collections of water. Malaria disappeared from many sections of the Central West after the ground was underdrained and cultivated. Small pools of water such as roadside puddles, accumulations in furrows and horse and cattle tracks, ruts, ditches, hollow trees, quarries, etc., serve as breeding places, especially for anophelines. Their elimination is generally a simple matter.

Water stored for domestic purposes in tanks, cisterns, barrels, etc., are ideal breeding places for mosquitoes, especially calopus. With the introduction of modern municipal water systems in West Indian, Central, and South American cities this danger is abating. The greatest care must be taken to protect domestic water supplies from mosquitoes. Wells must be tightly covered, and pumps, not buckets, used to draw the water. Precautions must be taken as to the covers of water barrels. Galvanized iron covers or closely fitting hooped screens of wire or some fabric such as gauze or burlap, preferably wire, should be employed, wooden covers generally failing to keep out mosquitoes, as they are apt to be ill-fitting or warped; nor should any be removed except for cleansing or refilling the barrel, spigots being preferable for drawing the water. The covers of cisterns and tanks must be well fitted, and the joint must be protected with wire gauze screening, as wood is prone to shrink and warp. The inlet must be protected with both

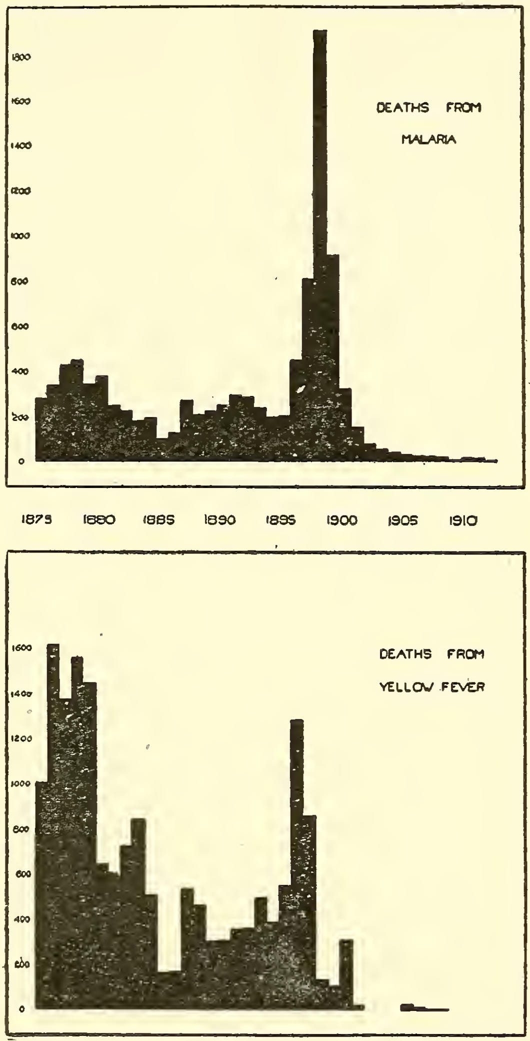


Fig. 18.—Chart Showing the Conquest of Mosquito-borne Diseases in Havana, Cuba. (*American Museum of Natural History, New York.*)

coarse and fine-meshed screening to prevent stoppage by leaves and other litter, and must extend below the water surface. In cases of emergency the water may be protected by some oil that is inoffensive or tasteless, such as olive oil.

Privy vaults and cesspools must be kept covered with petroleum, frequently renewed.

The domestic mosquitoes will breed in every available body of water found around buildings, preferring, however, clean water. Watering troughs for horses, pans for fowls, irregularities in rain-water gutters, cans, bottles, cocoa-nut shells, etc., are all used and their eradication or protection against access is an important part of anti-mosquito work.

Destruction of Larvæ. When draining or filling is impracticable, fish may be used to destroy the larvæ. They may be introduced into the breeding places by ditching from other bodies of water such as streams or the sea. Artificial lakes, ponds, fountains, etc., may be stocked with minnows, preferably "millions," or gold fish. As the mosquitoes breed near the margins of rivers and ponds the growth of aquatic vegetation should be controlled in order that the fish may reach the larvæ.

Oiling the surface of breeding places is expensive, but sometimes necessary. A film of petroleum on the surface of the water suffocates the larvæ and pupæ and to a certain degree prevents the female from depositing her eggs. The lighter grades of oil should be used and the entire surface covered, plying it with sprinkling cans, mops, or hose, renewing the film from time to time, generally about once a week.

The best larvacide is the one used in Panama:

Phenol	150 gallons
Powdered resin	150 pounds
Caustic soda	30 pounds

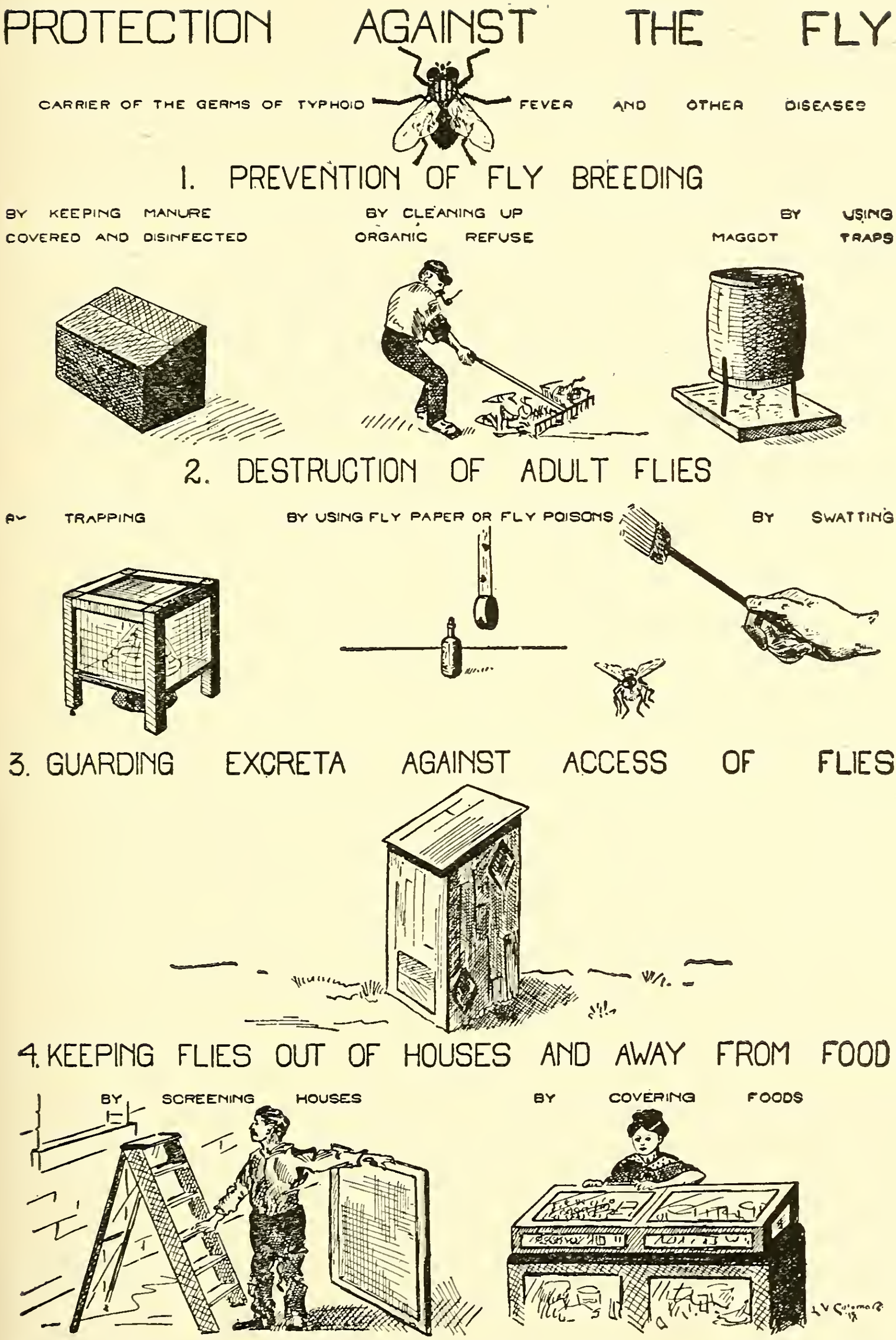


FIG. 19.—CHART SHOWING FLY CONTROL MEASURES. (*American Museum of Natural History, New York.*)

The phenol is heated to and kept at 212° F. and the resin added, followed by the soda, and the mixture stirred until a dark emulsion without sediment is formed. The larvacide is mixed with five parts of water and five parts of crude petroleum and sprayed or allowed to drip upon the surface of ponds or streams.

Various chemicals, such as the mineral acids, sulphate of iron, sulphate of copper, permanganate of potassium, bichloride of mercury, phenol, and other coal-tar products are efficient in relatively large quantities for non-potable water.

Destruction of the Insects. This is discussed in detail in the section on "Insecticides."

FLIES. The common house fly can only be suppressed by eliminating its breeding places. As 90 per cent. breed in horse manure and the remainder in other organic refuse, the means to this end are obvious. In cities with competent health departments the matter is comparatively simple, especially if the inspectors have sufficient authority to enforce the regulations. In the country, where stables are as a rule not so well constructed and the manure is desired for fertilizer, the problem is more difficult. The "swatting" campaign against the fly is only indirectly of value in attracting attention to the possible dangers of infection by the insect. Relatively, the actual number of flies destroyed is unimportant. It is not to be relied upon, as it attacks the problem at the wrong end.

Flies lay their eggs in stable manure as soon as it is excreted, therefore the manure should be placed in tightly covered bins, barrels, or pits, and removed once a week. This makes unnecessary the use of insecticides on the manure and prevents the hatching of the eggs on the premises, as a period of ten days is required for incubation. In towns and cities it should be removed, as is other refuse, by the municipal authorities. Most manure from cities, as well as from rural districts, is eventually used as fertilizer, and the eggs are hatched wherever transported, even if the manure is plowed under or buried. While fly breeding can be overcome in a given locality, no practical means for its general prevention has been found.

Receptacles for manure should be water tight, but if bins are used they may be connected with the sewer, and so covered as to prevent the entrance and exit of flies, nor must they be overfilled or allowed to remain uncovered. In densely populated districts manure should be transported in closed vehicles or be covered during transportation by canvas, to prevent dropping.

When it is impracticable or undesirable to remove manure it should be stored in dark, covered, or screened places. Insecticides, preferably coal oil, may be poured on the manure to kill the larvæ. This and other chemicals, including chloride of lime and Paris green, are uncertain in their action and require frequent renewal.

Slops and garbage should be kept in well-covered receptacles, preferably of galvanized iron, water-tight, and rat-proof, cat-proof, and dog-proof, and must be frequently removed, especially during the fly season. The refuse that accumulates about market places, slaughter houses, tanneries, breweries, on wharves, in alleys, and in vacant lots in cities where sanitary inspection is defective is a nuisance that must be abated in order to suppress fly breeding.

General cleanliness and good repair should be observed about stables and other places where animals are kept. The flooring should be water-tight and well drained, as flies at times breed in urine-soaked boards and in contaminated ground under and around stables.

In rural districts where the prevention of fly breeding is a practical impossibility, the houses, dairies, and privies should be screened and the food supplies kept in fly-proof receptacles.

The destruction of the adult fly is described under "Insecticides.'' The method of poisoning by dilute, sweetened formalin solution in saucers placed around the house, the use of fly traps, electric fans, etc., are familiar to all, but at best are makeshift methods and only dispose of a limited number of flies.

The suppression of the tsetse fly, *Glossina palpalis,* that transmits *Trypanosoma gambiense,* the cause of the ''sleeping sickness'' of Africa, is most difficult. The larvæ undergo transformation to the adult stage in moist soil. Exposure of the land to the sun by clearing the brush dries the soil and kills the pupæ. This has been found somewhat effective around native villages, settlements, trading posts, wharves, etc.

As the tsetse fly feeds on the blood of vertebrate animals, including the crocodile, the suppression of its food supply has been suggested. This is obviously impracticable.

Fleas. The adult insects are killed by the general insecticides, particularly hydrocyanic acid gas, sulphur dioxide, and carbon bisulphide. When the use of gaseous insecticides is impracticable or undesirable, infested apartments, furniture, etc., may be treated with liquid or powdered pulicides. Thorough scrubbing with hot soapsuds or the application of tincture of green soap is effective. Coal oil and benzine freely sprinkled in the infested places destroy the insects. Old floors, mattings, and carpets require particular attention. The larvæ, developing in the cracks of floors and in other crevices and interstices, may be killed by flaked naphthalene sprinkled on the floor and left in the closed room overnight. This material may be used more than once.

Pyrethrum powder is quite effective applied about beds or other furniture and on animals. After the use of the powder on animals the stupefied fleas fall off and should immediately be swept up and burned. The resting and sleeping places of infested dogs and cats should be provided with a piece of carpet or matting which should be shaken from time to time

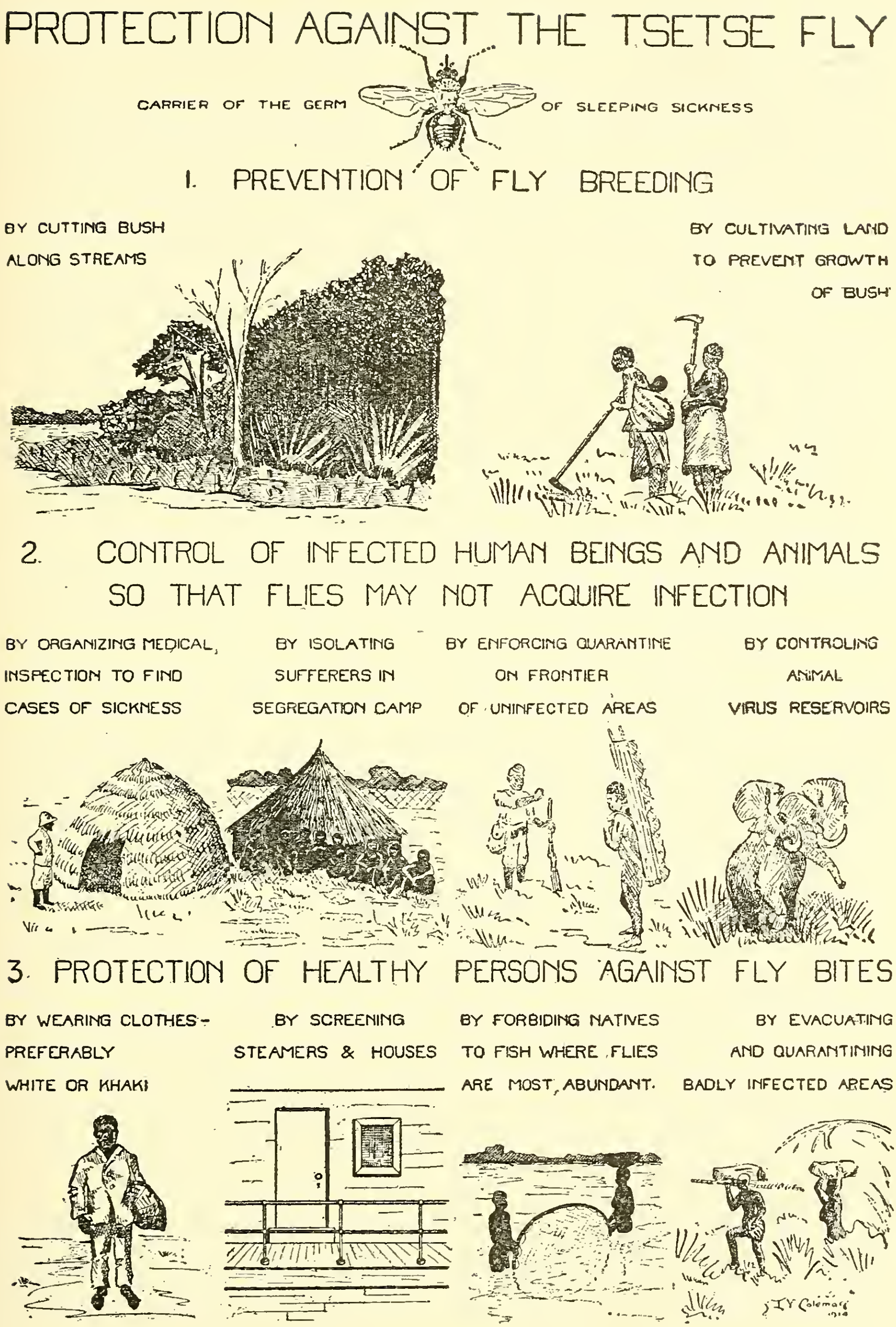


FIG. 20.—SHOWING METHODS OF PROTECTION AGAINST THE TSETSE FLY. (*American Museum of Natural History, New York.*)

into the fire, thus destroying the eggs, larvæ, and fleas with which it is sure to be covered.

Chloroform and ether first anesthetize and then kill fleas. Bichloride of mercury, formalin, phenol, and tricresol in the strengths used as antiseptics have little or no value.

Lice. Three species of lice are found on man: (1) *Pediculus humanus capitis,* commonly inhabiting the scalp. (2) *Pediculus humanus corporis* or *Pediculus vestimentorum,* living in the clothing and on the body. (3) *Phthirius pubis* or *Pediculus pubis,* the crab louse, found only on parts of the body covered with short, coarse hairs—the pubic and perianal regions, the axilla and more rarely the eye brows.

Lice are avoided by personal cleanliness, such as frequent bathing, change of underclothing, and keeping the hair short. Occasionally, however, the most fastidious person becomes infested from hotel beds, berths aboard ships, from sleeping cars, carriages or contact with vermin-infested individuals. Phthirius pubis is conveyed to another by contact in lodging houses, houses of prostitution, bath tubs and toilet seats. Different measures are required to destroy the different species. The adult insects have but little resistance, but the eggs are more difficult to eliminate.

Infested scalps should be treated with equal parts coal oil (kerosene) and olive oil or with equal parts coal oil and vinegar, well rubbed in, and the head covered with a piece of muslin overnight and shampooed with soap and hot water in the morning. The nits are then removed with a fine tooth comb wet with vinegar. This process must be repeated on two or three successive nights. In severe cases it may be necessary to cut the hair short or shave the scalp.

Body lice are killed by boiling, baking, or steaming the clothing, or it may be ironed, particularly the seams, with a hot iron. The clothing may also be treated with hydrocyanic acid gas, sulphur dioxide, carbon bisulphide, or chlorpicrin. Dipping in phenol solution is also effective. As some of the nits are attached to some of the finer hairs, a bichloride of mercury bath is desirable.

For pubic lice the best remedy is mercurial ointment. White precipitate ointment and tincture of larkspur are also serviceable. As mercurial ointment may cause dermatitis some prefer to shave the infested region. The avoidance of public and unclean water-closets and illicit sexual intercourse are desirable as prophylactic measures.

Ticks. The destruction of ticks is confined of necessity to those infesting domestic stock. The arsenical dip is now the approved method. The following is the formula given by Rosenau:

Sodium carbonate (sal soda)	24 pounds
Arsenic trioxid (white arsenic)	8 pounds
Pine tar	2 pounds
Water	q. s. to make 500 gallons

Crude oils are more expensive and not without danger to the cattle in dry regions and where it is necessary for them to be driven after the dipping. When dipping vats are inaccessible the solution or crude oil may be applied with spray pumps, mops, or brushes. To protect the cattle properly they must be dipped or treated about once a week.

In the case of *Dermocentor venustus*, the tick transmitting Rocky Mountain spotted fever, efforts have been made to reduce the number of rodents who, among other wild animals, are infested with the parasites. The brush which harbors the tick in the infested districts has been partially cleared and the result is somewhat encouraging.

In certain regions where ticks abound, especially Central Africa, great personal and domestic cleanliness must be practiced to avoid tick bites. As the *Ornithodorus moubata*, transmitting the relapsing fever of Africa, is nocturnal in its habits, sleeping on the ground must be avoided, a properly arranged mosquito net with the bed well off the ground being essential. A night light is also desirable in keeping away the ticks. The bedding of travelers, explorers, and sportsmen must be carried in metallic, insect-proof cases.

Bedbugs. By reason of its habits of concealment, *Cimex lectularius* is hard to reach by ordinary methods. Little difficulty is encountered in eliminating them from iron or brass bedsteads, but once old wooden bedsteads or the cracks and crevices of walls and floors become infested the matter is very difficult. Fumigation with the gaseous insecticides, hydrocyanic acid gas, sulphur dioxide or carbon bisulphide, is effective. If the furniture or other articles are not injured thereby, scalding water or soap suds liberally applied may be used to destroy both eggs and insects. Any of the petroleum oils, benzine, coal oil, or gasolene, may be sprayed or injected into the infested crevices. Oil of turpentine or saturated solution of bichloride of mercury are of value used in the same manner. Any of the above liquids may be applied to cracks and crevices by means of small brushes or feathers.

Rats and other Rodents. To exterminate the rat is a physical impossibility. During the fight of the past twenty years against plague many millions have been destroyed, particularly in the countries bordering on the Pacific and Indian Oceans, but they are apparently as plentiful as ever. They may be cleared from a building, small district, or ship, but their general extermination is impossible. The fact that they are seldom seen in the desirable residential districts of cleanly cities shows that with decently-kept habitations and municipal cleanliness nothing is to be feared from rats and their diseases. The degree of rat infestation is inversely as the amount of rat-proofing and directly as the amount of rodent pabulum.

Rat-proofing and other measures for the extermination of mammalian vermin were first introduced for the eradication of bubonic plague. In no other way can that disease be con-

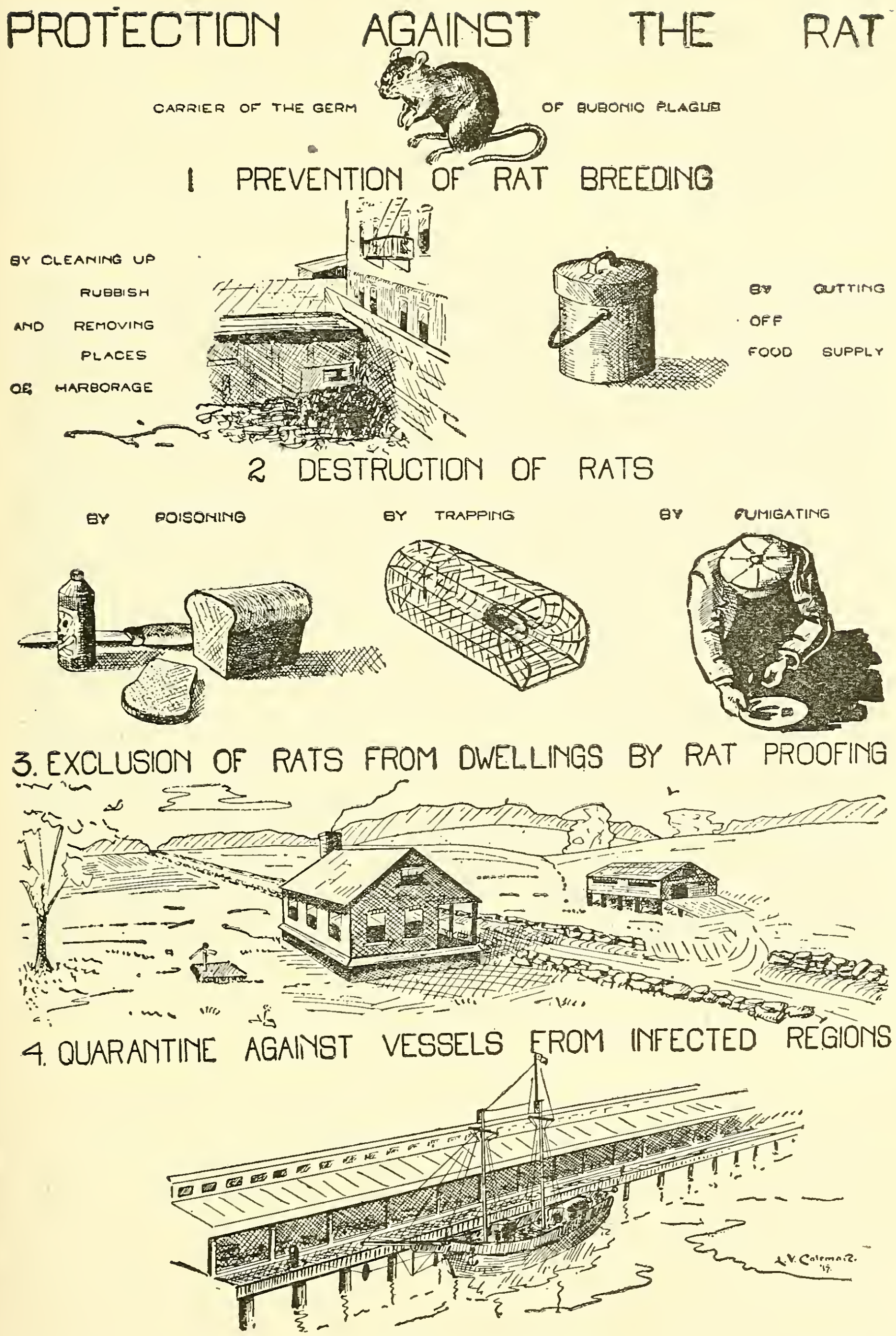


FIG. 21.—CHART SHOWING RAT CONTROL MEASURES. (*American Museum of Natural History, New York.*)

trolled, since in no other manner can the transmitting agent be kept from intimate contact with man. Until plague-harboring rodents are so excluded plague will occur among human beings so long as it continues among rats.

In addition to plague a number of other diseases, including a leprosy-like disease, exist commonly among rats, the organ-

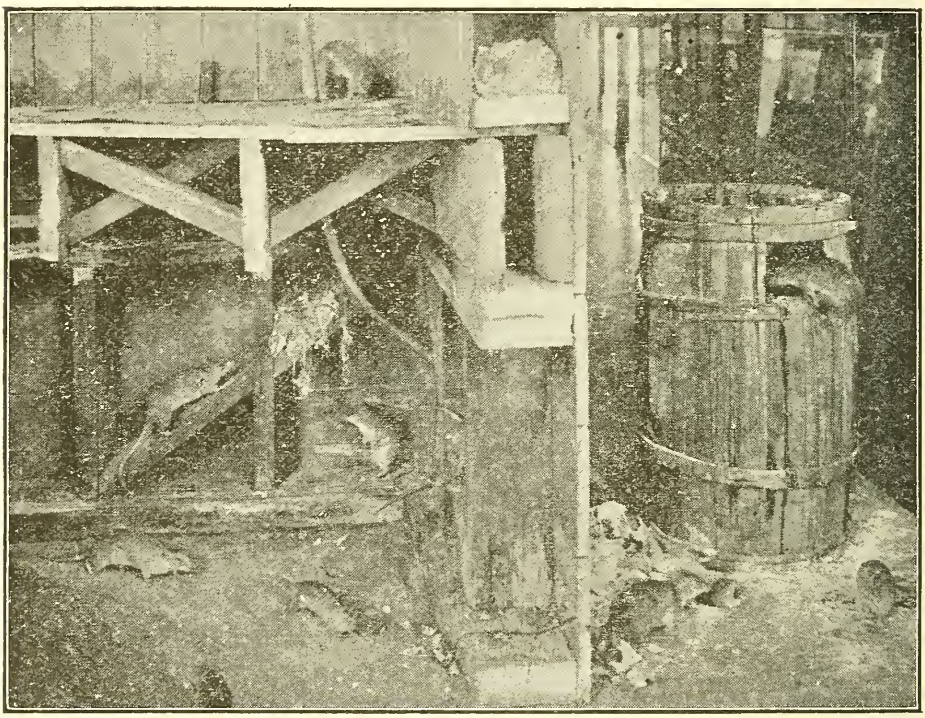


Fig. 22.—Conditions that Favor the Breeding of Rats. (*American Museum of Natural History, New York.*)

isms of which are believed to be capable of infecting man. "Trench fever," an apparently ephemeral fever occurring in the European war zones, is under suspicion as being derived from the rats that infest the trenches and dug-outs. They are the hosts of a number of ento-parasites, while ectoparasites such as fleas, lice, and ticks infest their loathsome bodies. They are afflicted with new growths, both of the benign and malignant types. If we accept the parasitic theory as to the etiology of the latter, the possibility exists that rats are a factor in the dissemination of cancer.

The application of rat-proofing methods indirectly affects the transmission of other diseases, thus conferring far-reaching sanitary benefits on the community. Other vermin, such as roaches, lice, bedbugs, and ants, are reduced in number. The improved character of remodeled and newly-built rat-proof structures, by the better protection or removal of human and animal discharges and food waste, contribute to the prevention of communicable diseases. The rat-proofing of stables improves the health of horses. The improved manner of handling manure and the proper removal of animal discharges militate against the breeding of flies and the spread of typhoid fever and tetanus.

The installation of expensive rat-proofing methods is generally followed by such minor repairs as renewal of screens to doors and windows, the repair of defects in plumbing, the installation of modern wash-basins and sinks, and the more cleanly storage of raw food-material. Such improvements in candy factories, sausage factories, soda-water stands, cracker and biscuit factories, and food establishments of a similar character, improve the methods of manufacture and handling and assure cleaner products.

In some cities and towns cisterns of wood or metal, resting on the ground, are continued in use after the establishment of a modern water supply system. The foundations of such structures are good rat refuges and should be reconstructed. On account of the high cost of repairs the owners generally prefer to demolish the cisterns. A breeding place for mosquitoes is thus eliminated and the use of dirty water from roofs is prevented. (Rucker.)

The general sanitary standard of cities is raised by rat-proofing. The incidental intensive inspections reveal a surprisingly large number of insanitary toilets without sewer connections. Much improvement results from their repair or demolition and the installation of modern plumbing.

Structural changes are necessarily expensive, but when properly carried out are of great economic value. Rat-proofing makes lasting improvements in the structural condition of buildings, and there are less frequent expenditures for repairs. When applied to habitations the annoyance due to the presence of rats is removed and loss from destruction of food products is prevented.

The rental value of premises is enhanced through the use of modern methods of construction and the introduction of modern sanitary fixtures, and fire risk is decreased by the use of non-combustible materials in the remodeling and construction of rat-proofing structures.

Permanent rat-proofing requires the construction of floors impervious to moisture, enabling them to be maintained in a clean condition with little difficulty, thus permitting the cleanly handling of food-stuffs. When impervious floors are installed in food depots such as wharves, warehouses, wholesale and retail grocery establishments, etc., they permit the recovery of food accidentally spilled, resulting in the saving of material which otherwise would be contaminated and be subject to waste. The cost of handling material, due to reduction in amount of physical labor expended, is less in warehouses with concrete floors than in others not so constructed.

The suppression of rats will be discussed under the following headings: (1) Rat-proofing. (2) Starvation. (3) Fumigation. (4) Traps. (5) Poisons. (6) Shooting. (7) Natural enemies.

Rat-proofing. Every premises occupied by man in plague-threatened communities should be rat-proofed, not only dwellings, but stables, markets, slaughter houses, warehouses,—especially provision warehouses. Manufacturing and mercantile establishments, docks, outbuildings, etc., in cities, and barns, granaries, corn cribs, etc., in the country must be protected. No port without rat-proof docks is safe from plague, and as plague generally appears first along the water front, being brought by infected rats on ships, the rat-proofing defenses should be particularly strong in that locality.

In rat-proofing buildings the following factors are important: The use of concrete on ground areas; stoppage of accidental openings around plumbing and electric wiring; abolition of spaces in double ceilings; closure of roof openings by wire gratings.

Concrete is ideal rat-proofing material either for buildings or wharves. It should be applied in the form of a side wall at least 2 feet below the surface of the ground and 1 foot above the ground level. This prevents burrowing underneath the concrete floor and the gnawing of holes at the junction of the floor with the side wall, which would give access to the space between the outer and inner walls. If there is a basement it should be floored with concrete, have a brick or concrete side wall, and should not have a double ceiling. If there is no basement, the area under the ground floor should be filled in, and on this filling should be spread a tamped layer of hard cinders, gravel, or cracked rock, and on this should be laid a concrete floor with a smooth surfacing. The ceilings of the other stories should, if practicable, be removed, thus doing away with the bottom of the box-like structures which serve as habitations for rats. Where this is impracticable entrance to the space should be prevented by the use of metal flashings, preferably of galvanized iron, extending 6 inches on the floor and 6 inches up the side wall.

The lower parts of the doors of markets, wharves, etc., should be sheathed in metal to keep the rats from gnawing through. Basement windows should be protected by screens, and doors should be kept closed by springs. Drain pipes must not be left open. Rat-holes should be closed with a mixture of cement and broken glass or crockery. Accidental openings around plumbing and electric wiring must be stopped, preferably by concrete or by the use of metal rings fitting close to the surface. Water pipes and drain pipes should be surrounded by cement, and roof openings must be closed by wire gratings or screens.

Where the brown or Norway rat abounds special attention should be directed to ground areas. The black and Alexandrine rats, being climbers, must be guarded against by careful protection of roof openings. It should be borne in mind that as the fiercer Norvegicus is killed off the black and Alexandrine rats increase materially.

As no rat-proofing is absolute security against the entry of rats, conditions in the building should be made so that no refuge may be found by them after entry. No rubbish in which they can nest should be allowed to accumulate.

Stables should be rat-proofed as thoroughly as the foregoing structures. The floors should be concrete and well drained; stalls should have a grating of wood to prevent the animals from slipping and from getting "stove up"; mangers should be metal lined; the grain bins should be metal lined and the manure kept in metal-lined containers or in concrete pits and removed at frequent intervals.

The foregoing type of class of rat-proofing is styled Class A, and is used in food warehouses and other buildings to which rats are apt to be attracted.

In the country, corncribs, barns, granaries, etc., must be protected by the use of galvanized iron sheeting and netting and by cement used in their construction.

Rat-proofing of residences is a simpler matter. The house may be elevated on brick or concrete piers at least 18 inches from the ground and the space underneath left free of access to cats, dogs, and light, rats being averse to well-lighted spaces. In frame dwellings the space between the uprights should be stopped with concrete or brick to prevent the entrance of rodents into the hollow wall. This is rat-proofing by elevation, and is applicable to many different structures in many different ways.

A solid "chain" wall may be used instead of elevation—a method that is satisfactory if the ground flooring is well built and in good repair. The ventilators within the walls should be metal.

The use of elevation and chain walls is styled Class B rat-proofing.

The value of rat-proofing may be largely neutralized by a bad condition of outside premises. Material covering yards, sidewalks, alleys, and passage-ways which permit rat refuge should be removed. Wood and lumber piles should be rat-proofed by elevation 18 inches above the ground. Outbuildings that harbor rats should be protected against their entrance.

General cleanliness of environment must be practiced Water-tight metal garbage cans must be used and the garbage regularly collected, and all waste products from factories, stores, hotels, breweries, etc., disposed of promptly.

Starvation. Through careful protection of food supplies stored in provision stores, warehouses, hotels, residences, etc., by metallic receptacles and the use of wire netting in the form of cages, starvation of rats can be accomplished. Well-covered metal garbage cans are essential. Organic refuse must not be deposited on the ground, and the offal from slaughter houses and the waste from breweries must be frequently removed and, if possible, burned. Wharves and warehouses must be kept clear of vegetables and other articles of food dropped in handling and transportation. Scraps of lunches in office and other buildings must be disposed of carefully.

Fumigation. Rats are killed in closed spaces by sulphur dioxide, carbon bisulphide, hydrocyanic acid gas, or carbon monoxide. Sulphur dioxide is most useful, especially in ships, stables, cellars, sewers, etc., where no damage is done to articles or structures by the action of the gas. Hydrocyanic acid gas is the most effective and, under intelligent supervision, the gas of choice for killing rats or any kind of vermin. The methods of generating the different gases are described under "Disinfection and Disinfectants" and "Insecticides."

Traps. Systematic and intensive trapping reduces the number of rats considerably. As many female rats are caught numbers of pregnant animals and potential mothers are killed. Many rats caught in different parts of a city should be examined bacteriologically to determine the presence or absence of plague among them. No seaport should be considered free from plague until such a rodent survey has been made and the absence of plague-infected rats assured.

Snap traps, because of their small size and general adaptability, will be found most useful for general use. They should have strong, hard-wood bases, with the springs and wires securely fastened to the base. The efficiency of such traps is increased when provided with a double acting trigger release, with hooks for attaching bait. The so-called Federal trap is the best.

Traps should be placed where they will interrupt the runways of rats—under floors, above ceilings, at wall margins, and on girders, cross-beams, ledges, etc. As rats more frequently run in contact with walls—guided by their vibrissæ—than in the open, it is useful to place the traps against the walls. They should be securely anchored with small pieces of strong twine, and should be frequently cleaned and oiled. Smoking, to destroy the odor of human beings, is not essential.

Cage traps are of particular value in sewers, but may be employed in any position affording sufficient room. They may be covered with loose sacking, hay, or other material, or left bare. Such traps should be about 20 inches long, all wires well braced and the release pedal "ledged."

The habit of rats of traversing dark passages may be utilized by having a pipe lead to the door of the cage trap. Cage-trapped rats should be chloroformed or killed in some other humane manner. Other forms of traps are the guillotine trap and the barrel and pit trap. When traps are being placed in buildings, upper floors, attics, and roofs must never be overlooked, since these locations form the natural habitat of the roof rat.

The small amount of bait required by individual householders for rat-trapping is easily secured from the family larder, but when extensive trapping operations are carried out over large districts the cost of bait is a considerable item. The material selected should be the cheapest obtainable consistent with its rat-attracting qualities. For snap traps, bacon, cheese, scrap-meat, bread soaked in lard, or shelled nuts may be used; for cage traps bread dipped in grease, cheese, scrap-meat, vegetables such as cabbage or carrots are most efficient. Black rats relish dried raw meat.

It is well to have a rat, preferably a female, in cage traps as a decoy.

Poisons. Poisons are of some service in reducing the rodent population of wharves, stables, granaries, etc. Poisoned rats are apt to die on the premises, therefore the method is undesirable in dwellings on account of the odor from their dead bodies, also most of the poisons are dangerous to children and domestic animals, including poultry. Rat poison should not be placed in unprotected places, but in localities where it may be reached by the rats only, not by children and domestic animals.

The most effective poisons are those containing phosphorus or arsenic, both kinds being purchasable in the open market. Phosphorus is dangerous on account of its liability to spontaneous combustion, but is valuable because the phosphorescence attracts the rats and because it is unstable and therefore does not remain indefinitely dangerous to children and animals other than rats. On the other hand, arsenic trioxide suffers little deterioration on exposure, and is dangerous for that reason. Strychnine and barium carbonate are also used. Rats show considerable toleration for the former and do not like the metallic taste of the latter. Strychnine is also dangerous because of its stability. Yellow phosphorus is mixed with glucose or other menstruum in the proportion of 1 to 4. Arsenic trioxide (arsenious acid) may be mixed with lard or corn meal in the proportion of 12 to 1. To the latter may be added white of eggs. Crystals of strychnine may be incorporated in cheese, meat, or sausage.

The biological poisons are quite expensive and almost useless. The bacterial rat viruses belong to the colon-typhoid group of bacteria and closely resemble *Bacillus typhi murium, Bacillus enteritidis* or *Bacillus paratyphosus B*. They are not without danger to man.

The Danysz virus (*B. typhi murium*) is pathogenic under ideal laboratory conditions, but the artificial epizoötic spreads feebly and soon dies out under natural conditions.

Shooting. In large buildings and on wharves this method of rodent destruction is somewhat effective. The evening is the best time, as the animals are then on the hunt for food. Continued shooting seems to drive away the survivors.

Natural Enemies. The killing off of the carnivores, mammals and birds, that are the natural enemies of the rat has aided the increase of the pest in America. The rats are more destructive to eggs, poultry, and small game than hawks, owls, coyotes, foxes, skunks, weasels, minks, and ferrets, all of which destroy rats in great numbers. Small dogs such as fox, Irish, and Scotch terriers, make good ratters, and are particularly valuable on farms. Large dogs and curs are of no value for this work. Most cats will catch mice, but hesitate to encounter the larger rodents. Cats and dogs used as ratters should not be allowed to enter homes during the prevalence of plague.

Other Rodents. Plague is endemic among the ground squirrels, *Citellus beecheyi,* of California. Fleas have transmitted the disease to them from rats. The booby owl, that lives in the burrows with the squirrels, perhaps carries the infection by transporting fleas. The squirrel flea, *Ceratophyllus acutus,* bites man, as does the rat flea, *Ceratophyllus fasciatus.* Plague has been conveyed to man by the bite of the squirrel.

The ground squirrel may be killed by the poisons used for rats, to which may be added oil of rhodium. An efficient means of destroying them is placing a ball of cotton waste the size of an orange, saturated with carbon bisulphide, in the warren and plugging the hole with moist clay. They are hard to trap, being very wary. Their natural enemies, the coyote, wolf, badger, mountain lion, skunk, and hawk, should not be molested.

Water. As prophylactic measures differ somewhat according to the source of supply of water, a brief statement of the immediate sources and possible means of contamination is in order.

Water supplies are derived from the following sources: (1) Stored rain water. (2) Surface waters, including lakes, rivers, reservoirs, gathering basins, pools, and tanks. (3) Ground waters, including wells, springs, and filter galleries.

Stored Rain Water. Where other water is lacking or unfit for use a wholesome supply is obtained by collecting and storing rain, which is the purest water in nature. The uncertainty of supply, except where rainfall is regular and frequent, is the greatest drawback to its use. A large amount is lost by evaporation from the cisterns in which it is stored. It is ordinarily collected from roofs, and in order to avoid contamination by bird-droppings, dust, soot, and litter that accumulate on roofs and in roof gutters, automatic devices should be employed that divert the first of the rainfall away from the conductors, but save the subsequent fall. To insure perfect cleanliness some form of filtration should also be utilized.

Cisterns should be constructed of cement, stone, brick, or slate, be accessible for inspection and cleaning, and should be kept covered to exclude light, which favors the development of plant life, and to exclude dust, insects, rodents, and other animals. Overflow pipes should discharge into the open air and not into sewers, and be protected by wire netting to prevent the entrance of trash and small animals.

With reasonable care little or nothing is to be feared from rain water in the transmission of water-borne diseases.

Surface Waters. For large public supplies surface water is the most available. It is subject to pollution by the following means: (1) Human excreta and sewage; (2) animal excreta; (3) industrial and household waste other than sewage.

Rivers and lakes are constantly polluted by sewers of communities along their borders, drains, privies, night soil that is dumped where it may drain into the water, and by excreta and waste discharged from ships and boats. Watersheds are polluted by habitations and camps located on them, and by picnic parties, sportsmen, tramps, and other uncontrolled persons. As it is impossible to guard against carriers and unrecognized cases of fecal-borne diseases, all excreta must be regarded as a possible source of infection. When it is absolutely necessary for human beings, such as members of construction gangs, to sojourn on a watershed, the sanitary arrangements for the disposal of excreta must be perfect. It has been suggested that laborers so employed be subjected to the Widal test before being accepted and also receive the typhoid prophylactic inoculation. Constant sanitary inspection and the ownership or control of as much as possible of the watershed is the ideal method of preventing sewage and other contamination of surface water supplies.

Epidemics of typhoid fever have been started by passing trains distributing excrement on the watershed.

Where the supply is drawn from an inhabited area, there is always more or less pollution by stables, pigpens, animals wading in streams and grazing on land draining into streams, roads, manured ground, etc. This is of rather secondary importance, but nevertheless objectionable.

The grave danger of discharging untreated sewage into water supplies near the intakes is now appreciated, especially in cities located on the Great Lakes. The outfalls have been changed in some instances and many communities have installed filters and sterilizing plants for purifying the water supply. Where the sewage of a city is discharged into the only available water supply of that or other cities it is absolutely necessary that it first be subjected to some form of treatment to remove the dangerous constituents. These processes are considered in the chapter on Municipal Sanitation.

Reservoirs are constructed by damming up some valley or other depression. It is well to clear the surface of organic matter and vegetation by first removing the surface layers of soil. This inhibits the development of vegetable micro-organisms and odors in the impounded water. As surface waters contain vegetation they should be kept exposed to the light and air, otherwise the vegetation will die and become objectionable.

Ground Waters. Most rural districts, many small communities, and some large ones use ground water as the source of supply. The public supply is stored in standpipes or reservoirs, preferably covered to exclude light. Domestic supplies are generally obtained directly from the source, small distributing tanks sometimes being used. Ground water, while destitute of plant life, contains mineral constituents, such as lime salts and nitrates, which are plant foods. Once started in ground water, vegetation may cause unpleasant odors and tastes. Being derived from wells, springs, and filter galleries, ground water is less subject to pollution than surface water, but under some conditions may become very dangerous.

Wells are arbitrarily classed as deep or shallow, and as dug, driven, or bored. A dug well is a hole dug in the ground deep enough to reach water and made impervious, except near the bottom, by lining with stone or brick laid in cement, or by large earthenware piping with joints made secure by beveled edges, to prevent the entrance of surface washings. Surface water must, therefore, pass through a sufficient depth of soil before gaining entrance to the well to insure its purity by filtration. The cover of the well should be supported on a curb, be water-tight, and have a trap-door for cleaning and inspection. Open wells are contaminated by dirt, trash, and small rodents, reptiles, etc. Pumps, and not "The Old Oaken Bucket," should be used to raise the water.

Driven wells are made by driving a succession of iron tubes screwed together into the ground until water is reached. The water enters the tube through a perforated foot attached to the first length. The water is raised by a pump and at first contains gravel and dirt, whose removal forms a pocket reservoir around the foot.

Bored wells are drilled through solid rock and other strata, and may or may not be lined with iron pipe backed with cement, depending upon the nature of the soil. It is sometimes necessary to blast at the bottom to allow the water to reach the well. Large communities may be supplied by groups of bored wells.

Artesian wells are bored through impervious strata until a stratum is reached in which the water is under hydrostatic pressure powerful enough to force it to the surface, or nearly so.

Wells, especially shallow ones, are subject to pollution through the seepage of sewage from privies, cesspools, broken pipes, night soil thrown on the ground, etc. Very deep wells have been polluted by filth gaining access to the water through such channels as fissures in rock.

Before constructing wells or cesspools property owners should give due consideration to the underlying geological formation, with a view to avoiding pollution of their water supply by their own excreta and the possibility of its contamination by their neighbors' cesspools, or of themselves polluting the latter's water supply.

Springs are subject to great variations in the volume of outflow. They are outcroppings of the water table, sometimes cease their flow completely during dry periods, and are liable, like other waters, to become polluted. They may become contaminated by seepage of sewage, etc., like wells, or may be polluted where they issue from the ground by human or animal filth, dead animals, etc.

Filter galleries are underground tunnels running near and parallel to rivers and lakes. They intercept the ground water on its way to the river or lake, and do not collect water percolating from the latter as was originally thought to be the case. Being practically horizontal wells, the same precautions that apply to vertical wells will guard filter galleries from pollution.

The Purification of Water. At times great changes known as self-purification take place in surface waters. These are the result of oxidation, subsidence, dilution, and the action of vegetation and bacteria. Aeration may cause changes in the organic constituents without perceptibly lessening the total amount. Dilution by rain, melted snow, and ground water affects the chemical composition favorably, but may increase the bacterial content, including pathogens, by causing a temporary pollution from street washings, dung heaps, etc. Sedimentation acts very slightly in swiftly moving rivers, but acts favorably where the current is slow, as at the mouths of rivers and in lakes, ponds, and reservoirs. Algæ and other low forms of vegetable life take up all kinds of organic substances, including fatty acids, amido acids, urea, and glucose, in the same manner that the higher forms oxidize the organic constituents of manure on fertilized ground. A high temperature favors the growth of microscopic plants and other organisms detrimental to pathogenic bacteria, hence self-purification occurs more rapidly in summer than in winter.

The methods of practical value for the purification of water are: (1) Storage. (2) Chemical treatment. (3) Boiling and distillation. (4) Filtration.

STORAGE. The storage of water permits the chemical and biological agencies instrumental in self-purification to act. Few pathogens survive a month's storage in reservoirs or ponds.

CHEMICAL TREATMENT. According to the process used water is purified either by the formation of insoluble precipitates which settle to the bottom, carrying suspended matters, including bacteria, in their descent, or by the addition of oxidizing agents.

Alum. Alum, or sulphate of aluminium, added in the proportion of ¼ to 1 grain to the gallon, to water containing a moderate amount of $CaCO_3$ or other alkaline carbonates, forms the insoluble, gelatinous aluminium hydrate, a flocculent precipitate which entangles suspended matter. The sulphuric acid set free in the reaction is neutralized by the alkaline base and the sulphate thus formed also carries down suspended matter. In case of deficiency of $CaCO_3$, lime water may be added.

The process requires careful supervision; the amount of alum used varies with the turbidity and the amount of calcium carbonate present in the water. If not enough is used, the result is incomplete; if too much, the alum remains in the consumed water and is harmful to the system. It is also objectionable in washing and in the bath.

Most waters require additional treatment by sedimentation, filtration, chlorinated lime or other physical or chemical means, alum forming only part of the process. The latter alone will not purify sewage-polluted water.

The hypochlorites and permanganates act as oxidizing agents, and their disinfecting power is due to this oxidation.

Both lose their identity in the water, and the slight increase of carbonates or traces of manganese remaining have little or no physiological action on the consumer.

Chlorinated Lime. When chlorinated lime, of which calcium hypochlorite is the principal constituent as far as this process is concerned, is added to water, the oxygen of the water and not that of the hypochlorite is liberated. The calcium hypochlorite reacts with the CO_2 and forms calcium carbonate; the liberated chlorine unites with the hydrogen of the water and forms HCl; the oxygen thus liberated oxidizes the organic matter in the water, including the bacteria.

The amount of chlorinated lime necessary to purify a given water varies with the composition of the water. In terms of available chlorin varying amounts are used, depending upon whether the water being treated is raw or filtered, its degree of pollution, etc. Disagreeable odors are generated when waters containing a large amount of organic matter, especially decomposing organic matter of any kind, are treated with hypochlorites.

This method is cheap, efficient, reliable and easy of application. It is adapted to the treatment of large supplies of water for military use and for civil camps, travelers, and explorers as well as for municipal water supplies.

Liquid Chlorine. At present the most popular use of chlorine in water purification is the application of it in gaseous form, the disinfecting action of which is essentially comparable to that of chlorinated lime. It is obtainable in metal cylinders as liquefied gas, and can be applied directly to the water at the source of supply by means of mechanical feeding devices. The quantities added are expressed in parts of available chlorine per million parts of water by weight, and the dosage, as in the preceding process, varies according to the nature of the water from a fraction of one part to several parts per million.

The process, when properly supervised, can make a large volume of water safe for drinking at a comparatively small outlay and is to be recommended particularly on account of compactness, simplicity, and ease of operation.

Permanganate of Potassium. This is a strong germicide, but is not dependable in the strengths generally used. If too much is used in springs, wells or reservoirs, fish, frogs, turtles, etc., will be killed and the water thereby polluted. As with other chemical agents, the action is not continuous; much of the permanganate is expended in oxidizing organic matter and nitrites before the bacteria are acted upon. The amount necessary for the purification of a water therefore depends upon its organic constituents.

In India, from which country favorable reports were received during cholera epidemics, the wells are disinfected by pouring an ounce or more (depending upon the size of the well) of permanganate dissolved in water into the well and the dilute solution thoroughly stirred. The rule is to add enough of the salt to give a reddish tinge to the water for 24 hours.

The method is relatively costly, only fairly efficient, rather difficult of application and quite slow in action. It is useful in times of epidemics of water-borne diseases for the disinfection of water in tanks aboard ship or in isolated wells, for use in the field and in military and civilian encampments.

Bisulphate of Sodium. In the strength of 15 grains to the pint this will sterilize polluted water in half an hour, its action depending upon the free sulphuric acid liberated. Its continued use would probably lead to digestive disturbances.

Metallic Iron. In this process the water is agitated with metallic iron, a portion of which is taken into solution as ferrous carbonate, the result of the CO_2 of the water attacking the iron. When the effluent is discharged into the air the ferrous carbonate is changed into flocculent ferric hydrate, which entangles the organic matter, including the bacteria. This is followed by filtration through sand and the result is practically sterile water.

The process is theoretically excellent but very costly. It is unsatisfactory with peaty waters whose organic constituents form soluble compounds with the iron.

Copper Sulphate. This salt has a certain degree of usefulness in the destruction of many algæ and other microscopic organisms, but is without value in water infected with typhoid, dysentery bacilli or cholera spirilla.

Ozone. Next to boiling, treatment by ozone is the most effective method of purifying water. If properly carried out the water is practically sterilized and the organic matter partially oxidized. It does not clarify the water and has little or no effect on mineral salts. Unless the water is previously clarified most of the ozone will be used up on the organic impurities and disagreeable tastes will be developed.

The method embraces the production of ozone in the atmosphere by brush discharges from dynamos and the bringing of this ozonized air into close association with the water. At the present writing it seems to be best adapted to sewage polluted water which is clear. On account of the expense and engineering problems involved it is only available for water purification on a large scale.

Ultra-violet Rays. This method is very effective in fairly clear water. The Cooper-Hewitt mercury vapor lamp made of quartz or fused mica is used, glass being opaque to ultraviolet rays. Many bacteria are killed in 5 seconds, the dangerous bacilli in 20 seconds and the resisting spores in 60 seconds. As colloidal material and turbidity interfere with the action of the rays, the water should be subjected to a preliminary filtration. The process does not clarify the water. The bacteria are killed by the direct action of the ultra-violet rays themselves.

The apparatus is comparatively cheap, is simple and promises well for the future.

Boiling and Distillation. Bacteria are killed and most, if not all, toxins and other poisonous substances of organic origin, are rendered innocuous by boiling. Inorganic poisons, such as lead, are unaffected. The alkaline carbonates and calcium sulphate are precipitated. The amount of organic matter is not diminished, but the disagreeable taste of boiled water is partly due to changes in the organic constituents. The loss of dissolved gases is the other factor in the change of taste. This may be rectified by agitation such as shaking or stirring in contact with the air.

The non-spore-bearing pathogens are killed by a temperature of 60° C. for 20 minutes, or 60° to 80° for a few moments. It is better, however, to actually boil the water to insure safety. The boiled water should be kept in covered buckets or stoppered bottles to prevent recontamination.

This method has only a limited use but is adapted to individuals, households, travelers, explorers, and military and civilian camps.

Distillation produces a chemically pure and sterile water. In distilling water the first portion is rejected because of the large amount of volatile impurities carried over, if such are contained in the water. The distillation is stopped before all the water passes over as reactions occur in the concentrated solution of mineral and organic matters whereby more volatile matters are formed and the distillate again contaminated. The taste is flat, due to the loss of gases and the presence of volatile matters. The latter, especially free ammonia, in the distillate from sewage polluted harbor water may produce nausea and vomiting in those drinking it.

Distillation is the method of obtaining pure water aboard ship, for human consumption and for use in the boilers.

Filtration. For the purification of water on a large scale slow sand filters and the more rapid mechanical filters are employed; domestic filters are used for limited supplies.

Sand Filters. These are large, shallow, preferably covered reservoirs. At the bottom is a system of disjointed or perforated drain pipes to conduct the effluent to a central tank from which it may be pumped. Above the pipes are successive layers of filtering material of progressive degrees of fineness, including coarse gravel or broken stone, fine gravel, coarse sand and fine sand, the latter free from clay, sharp grained, with the grains from .20 to .35 millimeters in diameter. The layer of fine sand should be about 3 feet in depth.

The water is delivered continuously to the surface of the filter and passes slowly through the various layers to the drain pipes. In America the rate is about 2,500,000 to 3,000,000 gallons a day per acre of filter bed. This requires a vertical motion of about 2 inches an hour. The water is kept automatically at a depth of about 3 feet.

The purification involves chemical, physical, and biological processes, some of which are not as yet thoroughly understood. Organic matter is nitrified and oxidized; many particles in suspension are strained out; about 99 per cent. of the bacteria and other microörganisms are removed, largely by the layer of bacteria, algæ, etc., that grows upon the upper layer of sand. Bacterial activity is very important in this vital process.

The upper sand layer becomes clogged in time by the mass of microörganisms and must be removed at intervals by scraping or shoveling. This layer must, however, never be allowed to get less than 12 inches in thickness. A filter is at its best after it has been in use some little time, and the sand grains for a considerable depth have become covered with a jelly-like substance and the bacteria are growing within the filter. The effluent from a new filter or one just scraped is little better than the unfiltered water and must be wasted. The filtrate should not be used until bacteriological examination shows that the filter has become effective.

Some waters containing much suspended matter, organic and inorganic, should have preliminary treatment such as settling basins, storage or chemical coagulation. The filtered water may be further improved by treatment with hypochlorite of lime or ozone.

Mechanical Filters. Water purification by this means involves preliminary treatment with chemical coagulants such as aluminium sulphate, sulphate of iron, etc., and the rapid passage of the water through a layer of coarse sand. The filters consist of underdrained concrete basins or wooden or iron tanks containing the sand, and equipped for mechanically cleansing the sand without removal and for the regulation of the flow of water. The colloidal flocculent precipitate of aluminium hydrate forms a layer with organic matter on the surface of the sand and mechanically strains out the bacteria. When the filter becomes clogged it is cleaned by reversing the current of water and agitating the sand by revolving rakes or compressed air.

It is well to allow sedimentation in basins after the coagulant is added and before filtration. This allows the chemical reaction to become complete and a large proportion of the precipitate to settle, thereby making the necessity for cleansing the filter less frequent.

The addition of the coagulant, generally sulphate of aluminium 1 to 2 grains per gallon of water depending upon the turbidity, reaction, and amount of calcium carbonate present, is regulated automatically. If too little is added the water will not be purified, if too much the effluent will contain the chemical, possibly in dangerous excess.

With intelligent operation mechanical filters are satisfactory and remove 95 to 99 per cent. of the bacteria from the water. Without this they are much inferior to slow sand filtration. They are particularly adapted to the South and West, where the river water is frequently muddy.

Domestic Filters. Except for the removal of gross particles, dirt, iron rust, etc., domestic filtration, as ordinarily practiced, is to be unqualifiedly condemned. In most of the filters the process is purely mechanical and removes nothing held in solution. If the water is infected or in danger of infection it must be boiled after filtration to insure sterilization. The fakes on the market are contraptions for attachment to faucets and contain such substances as stone, sponge, asbestos, felt, wool, ground glass, sand or animal charcoal. The latter, by reason of its oxidizing action, should be an efficient filtering medium and at first does remove many bacteria, but it soon becomes excessively foul and is impossible to clean. The calcium phosphate contained in animal charcoal is a nutritious pabulum for bacteria. Household filters are reliable for clarifying waters, especially if the turbidity is due to iron or clay, but for nothing else. The rapid passage of the water through most filters condemns them, off-hand.

There are two types of mechanical domestic filters that give satisfactory laboratory results: the Pasteur-Chamberland, made of unglazed porcelain, and the Berkefeld, made of diatomaceous earth. The bacteria are entrapped in the tortuous passages between the constituent particles of the filtering media. In from four days to a week bacteria, including water-borne pathogens such as typhoid bacilli, grow through the walls of the filter. The Berkefeld is not as efficient as the Pasteur-Chamberland, the interstices being larger.

Both types are hollow cylinders or bougies, closed at one end, enclosed in a metallic or glass case with sufficient intervening space for the water which is forced in by its own headway from the faucet. The water passes through the walls of the cylinder and is discharged through the open lower end.

To insure safe water the cylinders should be scrubbed in hot water, boiled or baked about once a week.

Food. Milk more frequently transmits the communicable diseases than any other food. It may originally contain or be contaminated with the germs of animal diseases or be later polluted with matter containing the exciting causes of human diseases. Fresh milk products such as butter and ice cream may also be dangerous. Milk is contaminated by the hands and clothing of milkers and others handling it who may be carriers, convalescents or contacts, or who may be nursing or otherwise in contact with frank cases. It may be infected by utensils or vessels washed in polluted water or by water used for dilution.

Prophylaxis in milk supply embodies the sanitary production of milk and its sanitary supervision from the cow to the consumer.

The following requirements must be met: (1) *Healthy animals.* (2) *Cleanliness in milking and handling.* (3) *Good quality and freedom from adulteration, dilution, and decomposition.* (4) *Freedom from animal and human infection.*

From the standpoint of the sanitarian the last is by far the most important, but it is dependent on the others.

To meet the above requirements the following sanitary regulations are necessary: (1) *The sanitation of the farm, including water supply and drainage, the surroundings of the cows, the barnyard and stables.* (2) *Supervision of the health and feeding of the cows.* (3) *Supervision of the milkers and the milking as to cleanliness, etc.* (4) *Care and preservation of the milk and regulation of dairies, bottling and selling establishments.*

Sanitation of the Farm. It is imperative that dairy farms have an uncontaminated water supply. This has a close relationship to pure milk. Surface water such as ponds, small streams, and rivers contaminated or in serious danger of contamination by sewage and surface drainage are undesirable as water supplies for dairy farms. Deep wells, springs, and cisterns should be properly constructed and protected from pollution. The source of a water supply should be at least 200 yards from privy vaults, cess-pools, stables, barnyards, pig styes, etc., whose drainage may pollute them.

Manure should be kept in manure pits, well covered or screened, or collected twice daily and packed into barrels for removal to distant fields. The stables and barnyards, with their surroundings, should be clean and free from stagnant pools and accumulations of dirt and refuse. The cows should have their own barnyard, preferably located on elevated ground to facilitate drainage.

Stables for milk animals should be constructed for that one purpose. They should be built of brick or concrete; one story is best, with no open second story hay-loft and no manure pits under the floor. When more than one story high the floors should be dust-tight and should never be of wood or dirt, but of tiles, brick in cement mortar or concrete with cement top. Ceilings and walls should be painted light-colored or plastered and whitewashed. The floors should be graded for drainage into a sewer or cess-pool.

Stalls should be about 4 feet wide, 7 feet long and 9 feet high, guttered at the foot for the drainage of urine into the sewer or cess-pool. The gutter should be iron or concrete and have a perforated removable cover. The stalls should be properly equipped for tethering the cows. The mangers should be concrete, with rounded corners for easy cleaning.

Stables should be well ventilated through windows or other openings. At least 600 cubic feet of initial air space should be allowed for each cow. The lighting, by windows or skylights, should provide about 4 square feet of lighting surface for each animal. The windows or skylights should be placed at intervals of about 20 feet. The windows, doors, and other openings should be screened against flies and mosquitoes. Privies and urinals should not be placed in stables. Pigs and other domestic animals should be treated as intruders. The buildings should be frequently emptied and aired and all parts of them washed down daily and disinfected from time to time.

Supervision of the Health and Feeding of the Cows. The milk animals must be kept in pastures with trees or sheds for shade and protection from inclement weather. They must have daily exercise but must not be overdriven or abused and must not be annoyed by flies and dogs. Fresh water and salt must be accessible. Their feed should be grass, fresh hay, corn, and other whole grains. No swill, household or brewery, nor rotten fruit or vegetables, nor marsh grass should be given the cows. They should be groomed and cleaned daily. Immediately before milking, the flanks, abdomen, and udder should be washed with warm water. The hair around the udder and on the tail should be clipped.

The herd should be examined daily for early signs of disease, and the general condition of the cows noted. No milk from animals that are greatly emaciated, physically exhausted, overexcited or frightened should be used. Local septic disease of the udder or teats debars the milk. All milk of cows suffering from general diseases should be excluded, as should that from cows having tuberculosis, diagnosed by veterinary physical examination. Sick and pregnant cows should be separated from the general herd.

The elimination of tuberculosis in herds by scientific methods is a serious economic question. To eliminate all dairy cattle reacting to the tuberculin test but apparently healthy otherwise would result in a serious diminution in the number of cows, great financial loss to dairymen, a lessening of the milk supply, and increase of cost to consumers. The only alternative to destruction of the cattle is pasteurization of the milk. If the milk is to be consumed raw the only protection against possible infection with tuberculosis is the regular application of the tuberculin test and the exclusion of the milk of all cows giving a positive reaction. "Certified milk" is produced under such conditions.

Supervision of the Milkers as to Cleanliness, etc. The dainty milkmaids seen in the chorus of light operas are unfortunately never seen in dairies. The slovenly slatterns and dirty fellows who ordinarily do this work leave much to be desired from a sanitary standpoint. Milkers should be reasonably healthy and free from local and general diseases. Their finger-nails should be short and the hands scrubbed and washed before milking. Special white clothes, including caps, overalls or aprons worn at no other time and frequently washed should be used. Communicable diseases in the families of milkers should be promptly reported. The decision as to whether the milker shall be excluded from his work depends upon the local conditions prevailing in each case.

The stable should not be swept or the manure disturbed immediately before or during the milking time. The air should be as free as possible from offensive odors and dust. There should be no loud talking, coughing, sneezing; tobacco spitting or other expectoration during milking. The hands should be dry and the milking done in a cleanly, quiet fashion about the same time every day, and the same milker should milk the same cows. The first few streams of milk are rich in microorganisms and poor in fats and should be discarded. Such part of the milk as may be polluted by flies, dirt, etc., or looks abnormal should be thrown out and not mixed with the general supply. Narrow-mouthed pails with the wire strainers covered with sterilized cotton or gauze should be used. The pails and other utensils should be boiled or sterilized by steam after preliminary scrubbing in a warm alkaline solution.

Care and Preservation of Milk and Regulation of Dairies, Bottling and Selling Establishments. The proper care and preservation of the milk must begin as soon as drawn from the cow. The straining and cooling should be done in an aseptic manner in separate buildings constructed for the purpose, not in the cow stables. Here the milk should be kept and handled during its preparation for market. The milk houses must be clean, with the interior whitewashed and the floor hard and easily cleaned. They should be well lighted and ventilated and kept free from dirty and predaceous cats, dogs, and children.

The temperature of the milk must be reduced without delay to about 45° F. If this is done by placing the tubs or cans in cold water precautions must be taken that none of the water enters the vessels. Milk should be kept at a temperature not above 50° F., preferably by refrigeration. The cans should be full and well covered and during transportation protected from excessive agitation.

Milk should be consumed while reasonably fresh. This is impossible in communities deriving their supply from a distance. Biological and chemical changes start in milk almost immediately after its production, therefore some method of preservation is necessary. The cheapest and most desirable is low temperature which inhibits the action of bacteria, thereby retarding fermentation and souring and the development of the pathogenic species. Cold does not harm milk which, if reasonably pure, will remain potable for several days if kept at temperatures under 50° F. Boiling for a short time destroys all the bacteria except the spore-bearers; these and their toxins can be destroyed by a temperature of 250° F. for 2 hours. Boiling for 15 to 20 minutes is ordinarily enough, as the spore-bearing organisms seldom contaminate milk. Sterilization and boiling make the milk less digestible, especially for infants. This is due to destruction of the ferments, coagulation of the serum albumin, changes in the lactose and salts, and driving off of the carbon dioxide.

Pasteurization is best accomplished by heating the milk to a temperature of 140° F. for 20 minutes. This kills all the known pathogenic microörganisms except the spore-bearers. It does not modify the milk ferments or change its digestibility, taste or appearance. The milk must be rapidly cooled and kept so after pasteurization, or the fermentation which is checked by lactic acid fermentation, which latter is destroyed by the heating process, will again increase to the detriment of the milk. This method of preservation furnishes a clean, healthful milk on a commercial scale that is safe for all uses, including infant food. As unscrupulous producers may rely on pasteurization to make unfit milk "pure," increased vigilance is required on the part of state and municipal inspectors and analysts. Under proper sanitary supervision it is a most excellent mode of securing safe milk and is best done in the final container, the bottle. This permits of no contamination subsequent to the process and before delivery to the consumer. The bottles are sealed with water-tight caps and immersed in hot water of the proper temperature for the necessary time and cooled by lowering the temperature of the water. This process is being modified in several ways and is well suited to commercial purposes.

Dairies, creameries, and other establishments where milk and milk products are sold or handled should only be used for this industry. They must be well lighted and ventilated. The interiors finished in tile or painted with a light colored oil paint to allow the use of hot water for cleansing purposes. The floors should be of tile or concrete.

Machines used for aeration, cooling and bottling must be kept aseptically clean; the latter must be sterilized by steam before every bottling. Milk cans should be of seamless metal or glass. Milk bottles should be closed with paper caps, sterilized and paraffined.

All utensils, including cans and bottles, require the greatest care in cleansing and sterilizing. They must first be rinsed in warm water, then scrubbed with a brush in hot soap or other alkaline solution, then sterilized by boiling or steam and finally dried and inverted in fresh air.

Milk should only be sold in stores that are kept in a sanitary condition. It should be kept at a distance from strong smelling or spoiled food products. The cover of the can should only be removed when the milk is dispensed. The refrigerator must be kept clean and free from odors, as milk and milk products readily acquire the latter. The refrigerator waste must have a proper discharge, preferably into an open sink in the store or basement.

Stores should have no direct communication with living quarters and no one should sleep in the store. It is desirable that the store be kept as free as possible of children and domestic animals.

The labels on the cans and bottles should bear the name of the dairy, the wholesale dealer, the date of milking, and the date of pasteurization.

To put in force the foregoing sanitary measures, regulations covering them in detail should be adopted by state and local authorities and the proper inspection and laboratory work and the necessary inspectors and analysts provided for by law.

The interest of the epidemiologist in food supply relates to infected food which may transmit communicable diseases through being eaten in the raw state. Prophylactic measures seek to prevent the possibility of contamination of food at any time, from its production to its consumption, and to prevent the sale of dangerously diseased portions of meat.

Prophylaxis in meat supply is carried out by veterinary inspection of the animals before slaughter and of the carcasses after slaughter, supervision of the handling of the meat and the inspection of slaughter houses. Much of this inspection work is very properly done by the Bureau of Animal Industry of the Department of Agriculture, but such inspection only applies to meat and meat products intended for foreign or interstate shipment. State governments should provide for the inspection and licensing of slaughter houses and slaughtering. Unless this is done by state or local authorities a large proportion of meat killed and consumed within the same state entirely escapes inspection of any kind.

The sanitary care of food animals is important and the rules given for the care of dairy cows, with the necessary modifications due to their difference in size and habits apply to all animals intended for food purposes. The building of barns, stables, pens, styes, etc., should be governed by the rules guiding the construction of shelters from the weather, and in the case of barns the principles of ventilation, drainage, and facilities for lighting and cleansing prescribed for dairy barns.

The herds should be inspected regularly to detect incipient disease and secure the early isolation of diseased animals. The tuberculin test should be used at stated intervals and the diseased cattle condemned.

To prevent the transmission of communicable diseases by meat the following procedures are necessary: (1) Prevention of infection of the meat. (2) Preservation and storage under proper conditions.

Prevention of Infection of the Meat. This is accomplished by strict asepsis and cleanliness of persons and places where meat and meat products are produced or handled. This includes slaughter houses, packing houses, warehouses, markets, stores, restaurants, cars and ships with their operating personnel.

The sanitation of markets, stores and restaurants can only be enforced by inspection under municipal authority. The cleanliness, habits, and methods of employees are of the greatest importance, as some of them are sure to be carriers of disease. The following sanitary points require supervision: (1) Protection of food against flies, dust, and dirt. (2) Clothing of persons handling food. (3) General conduct of business, whether cleanly or otherwise. (4) Construction of storage and sales places. (5) Provision for and location of water closets and lavatories in regard to store and salesrooms. (6) Provision for, condition and care of cuspidors. (7) Use of sales or storerooms for other purposes, such as sleeping quarters. (8) Health of persons handling foods.

The above remarks apply to all places where food is stored, handled or sold, cooked or uncooked, including ice cream factories, bakeries, and confectioneries.

The Preservation and Storage of Meat. Heat is the most reliable and effective method of sterilizing and preserving meat. By this means all parasites, animal and vegetable, are destroyed and a safe food is assured. In the household this is attained by cooking such as roasting, baking and boiling. For commercial purposes the meat is first sterilized by heat and then enclosed in hermetically sealed sterilized vessels. Canned food thus preserved will keep for an indefinite time.

Keeping meat in cold storage or freezing it inhibits the growth of bacteria and preserves it for long periods but not indefinitely. Frozen meats deteriorate rapidly after being thawed. This is a most valuable means for the preservation of meat for use at sea.

The preservation of meat by sugar and condiments such as salt, vinegar, and spices does not sterilize it but does prevent putrefaction and is effective for years.

Drying and smoking are old methods and valuable for certain kinds of meat under certain conditions, for instance, such as prevailed in the early days on the plains when buffalo meat was so preserved.

Chemical preservatives, including sulphite of soda, boracic acid, and borax are very properly prohibited by federal and municipal statutes and ordinances. They are all more or less toxic and, if habitually used, dangerous to health. Inferior and partly decomposed meat and meat products may be disguised and placed on the market as fresh and unspoiled food.

The general principles laid down for the prophylaxis of meat supply from quadrupeds apply to packing houses, etc., where poultry, game, shellfish and other sea food are handled.

Oysters and other shellfish should not be used when taken from water whose bacteriological count is higher than in that fit for drinking purposes. Typhoid and other fecal-borne infections from oysters and other shell-fish are prevented by the careful location of the beds and the transfer of doubtful ones to clear sea water until the bacteria have disappeared from the bivalves. From two to three weeks should be allowed for this cleansing.

The transmission of disease germs by fruit and vegetables contaminated by infected persons or by water or by sewage used as fertilizer is prevented by municipal inspection of food supplies, the prohibition of exposure to dust and dirt and preliminary washing.

Fomites. It is now a well demonstrated fact that it is persons, sick or well, and not things, that transmit communicable diseases in most cases. Nevertheless in isolated instances infection does occur by contaminated things or fomites. The source of infection being persons, the keynote of prevention is to destroy infection as near the source as possible, thus avoiding unnecessary contamination of bedding, clothing, utensils, etc., and rendering innocuous absolutely necessary contamination. This result is achieved by the intelligent practice by physicians and nurses of bedside disinfection of clothes, bedding and utensils, in other words, medical asepsis. If nothing leaves the immediate vicinity of patients without being sterilized the disease will not spread in this manner. Fomites, as such, will not exist.

Suppuration is the best and most frequent example of this mode of infection. The germs of suppuration, especially staphylococci, are found on practically everything, animate and inanimate. They resist drying and unless antiseptic precautions are taken almost every wound, accidental and surgical, will be infected. Aseptic and antiseptic surgery has vastly decreased the danger.

Wound infection by the bacilli of anthrax, malignant edema, tetanus and by bacillus aerogenes capsulatus is prevented by prompt antiseptic wound treatment, preferably with tincture of iodine. When infection with tetanus or malignant edema is feared, as in punctured wounds by bullets or sharp instruments such as nails that have been on possibly infected ground, the depths of the wound must be well cauterized and tetanus antitoxin administered as a prophylactic.

The life of most bacteria on fomites is so short, due to exposure to sunlight, absence of moisture, and lack of nutriment, that gross contamination is generally required to cause infection in this manner. Tubercle bacilli sometimes survive for months in damp masses of sputum on fomites. The fecal-borne pathogens can only live on fomites in masses of feces that retain some degree of moisture. It is therefore apparent that even decent cleanliness almost of itself eliminates the danger.

Such sanitary improvements as the abolition of the common drinking cup and the roller towel show the tendency toward a better appreciation of the value of personal hygiene. When the proletariat and the "man in the street" learn to wash their hands before eating, and properly cared-for toilets become the rule and not the exception the morbidity tables from communicable diseases will show improvement. More attention must be paid to the instruction of consumptives as to the disposal of sputum. Visiting nurses are doing this to advantage.

Air. The precautions formerly taken to prevent infection through the air are now known to be largely unnecessary. With the possible exception of smallpox and pneumonic plague, the general atmosphere around a sick person does not become infected. Droplets ejected in coughing and sneezing remain in the air for a short while within a radius of about 20 feet around the patient. The diseases in which the specific organisms are found in the air passages are transmitted in this manner. These include tuberculosis, diphtheria, measles, scarlet fever, influenza, whooping cough, the pneumonic form of plague and possibly pneumonia.

The precautions to be taken to avoid "droplet infection" are obvious and simple. Any person, whether suffering from a known infection or not, should hold a handkerchief or hand before the mouth and nose during the acts of coughing and sneezing. Except for professional purposes, well persons should avoid coming within a yard of patients.

There is real danger in long continued exposure in rooms in which tuberculous sputum has dried on the floor or other places and where the air contains coarse dust raised by dry cleaning, air currents, or continued mechanical vibration and jarring as in railway cars.

There is some evidence that pneumonia, diphtheria, erysipelas and other streptococcus infections and the fecal-borne diseases, typhoid, cholera, bacillary dysentery and infantile diarrhœa are at times spread by infected dust from dried discharges.

Prophylactic measures against this mode of infection depend upon the avenue of exit from the body of the infectious organisms. In diseases affecting the respiratory passages all oral and nasal discharges must be received into sputum cups containing the proper disinfectant solution or into rags, gauze or paper and immediately burned. In streptococcic infections the seat of infection must be dressed properly and the dressings frequently renewed and burned as soon as removed. In the fecal-borne diseases all alvine and urinary discharges must be received in the proper receptacles containing the necessary solutions for disinfection.

In smallpox and pneumonic plague rigid isolation in addition to bedside disinfection is obviously indicated.

CHAPTER V

DISINFECTION AND DISINFECTANTS

General Considerations. *Disinfection* is the destruction of the pathogenic germs or morbific agents causing infection.

Fumigation is the application of gas, smoke, or vapor to a closed space for the destruction of pathogenic germs or the intermediate hosts or carriers of disease, such as mosquitoes, fleas, flies, rats, etc. Disinfection and fumigation are synonymous in certain cases, but not necessarily so.

Sterilization is the absolute destruction of all microscopic life, whether infective or not, and is, therefore, more than disinfection, which destroys only the germs of infection.

A *disinfectant* is an agent capable of destroying pathogenic germs, and *germicide* is a synonymous term. Most disinfectants are strong enough to sterilize objects to which they are applied.

Antiseptics are agents capable of preventing the growth and activity of the microörganisms causing disease, fermentation, and putrefaction, but do not necessarily kill the germs. A disinfectant must be an antiseptic, but an antiseptic *may* not be a disinfectant. Saturated solutions of salt and sugar will prevent putrefaction and fermentation in meat, fruit, etc., but they will not kill typhoid bacilli.

Asepsis is the absence or exclusion of living microörganisms, and is equivalent to sterilization.

An *insecticide* is a substance used to destroy or kill insects, though not necessarily a disinfectant. A disinfectant may not be an insecticide. Pyrethrum is an insecticide, but not a disinfectant, while formaldehyde is a disinfectant but not an insecticide.

A *deodorant* neutralizes or destroys unpleasant odors. All deodorants are not necessarily disinfectants.

Fortunately for the human race, our environment is unfavorable to the growth and multiplication of most of the pathogens, which are largely destroyed or their infectious power weakened by the natural disinfecting agencies, viz., dilution, sunlight, dryness, natural filtration, and symbiosis. The results achieved by these forces of nature are better than those attained by fumigating processes as ordinarily practiced. Mechanical cleansing, dryness, and sunlight are invaluable in sanitation.

The modern conception of cleanliness means more than tidy-appearing rooms. Habitations must be kept clean in a biological sense. Stirring up dust with brooms and feather dusters will not accomplish this end. Not only must organic matter be removed by mechanical cleansing, the vacuum cleaner, etc., and by scrubbing and washing, but insects and other vermin and their feeding and breeding places must be destroyed.

No person who is not familiar with the causes and modes of transmission of the communicable diseases should attempt to direct disinfection work, as it requires great attention to detail, and neglect of some small matter may render useless the whole process and engender a false sense of security. In order to be sure of results, disinfection must be carried to excess, but not in a haphazard way, as was formerly the case. More accurate biological knowledge now enables us to select the objects most liable to transmit infections and treat them accordingly.

Terminal Disinfection. With the relegation of fomites to a minor rôle in the transmission of communicable diseases, terminal disinfection has ceased to hold the position of importance as a sanitary measure it formerly occupied. The faith of the public—unfortunately fostered by the medical profession—in disinfection and disinfectants, and especially in terminal disinfection, is positively childlike. This faith is responsible for the farcical use of disinfectants and alleged disinfectants around the house and in the sick-room during illness, and the attempts of misguided enthusiasts to disinfect apartments and entire houses during and after illness by dishes of chemicals and cloths wet with evil-smelling compounds. It is absolutely contrary to modern sanitary methods to allow discharges, and presumably infected material or objects, to accumulate for final or even occasional disinfection. They should be destroyed or disinfected, preferably with some form of heat, as soon as they can be secured. The necessity for terminal disinfection depends largely on the care that has been taken to preserve cleanliness and insure prompt bedside disinfection during the course of the sickness.

The results reported by Chapin in Providence and Doty in New York of the discontinuance of terminal disinfection certainly show that the process is largely unnecessary after scarlet fever, diphtheria, measles, and cerebrospinal meningitis. It is still used in New York in some cases, after death or removal to a hospital.

There is a possibility that terminal disinfection may prevent a small number of cases, and this would, especially in view of the present frame of mind of the public, make its *intelligent* use worth while. "Terminal fumigation for measles and for certain other frail and short-lived viruses may not be necessary, but disinfection of objects likely to convey disease will always be demanded." (Rosenau.)

Standardization of Disinfectants. It is impossible accurately to measure the strength of disinfectants, as there are factors influencing the life of bacteria that are beyond control. The strengths and time of exposure are not agreed upon by different competent authorities. Under the circumstances it is difficult to state safe minimum conditions under which a given disinfectant would be effective. Laboratory work and the results of practical experience must both be considered in judging the value of a substance.

The method of Rideal-Walker, modified by Anderson and McClintic, based on the carbolic coefficient, is the best method of comparing the strengths of disinfectants in solution, but it gives only the relative value of the influence of the various substances upon exposed bacteria under favorable conditions.

A low coefficient indicates a worthless germicide, while a chemical with a high coefficient may be worse than useless for practical work. The ideal disinfectant should be non-toxic to higher animals and non-corrosive to metals; should not bleach, stain, nor rot textiles; should not be offensive to the sense of smell; should be readily soluble in water, and if forming a suspension or emulsion, should remain as such; should have reasonable penetrating power; should be capable of action in both alkaline and acid media; should not be unduly influenced by the presence of organic matter, and should be at least fairly cheap. It would take many tests to pass upon all these factors. It is evident that the ideal disinfectant for all purposes does not exist, and there seems no immediate probability of its discovery.

Disinfectants

Disinfectants are divided into two classes: 1. Physical agents. 2. Chemical agents.

Physical Agents.—Light. Sunlight is one of the most active disinfectants known, but it is so uncertain and the rays so variable that it can be depended upon only as an auxiliary agent. Its disinfecting power is superficial, but rooms and objects may be sunned and aired to advantage after disinfection. Diffused daylight is effective in a diminished degree. Depending upon its brightness and such conditions as temperature, moisture, transparency, and composition of the containing media, most, if not all, of the pathogens, even the spores of anthrax, may be killed by a varying number of hours of sunning. The blue violet and the ultra-violet rays are the only parts of the solar spectrum having disinfecting power. The red and yellow rays have few, if any, germicidal properties. The electric light is somewhat effective if containing the proper rays. The roentgen rays are inert in this regard. The ultra-violet rays from the Cooper-Hewitt vapor lamp are now used to sterilize water.

Heat.—*Burning.* Heat is the disinfectant *par excellence.* It is unfortunate that all infected and presumably infected material cannot be burned. However, all infected articles of little or no value should be destroyed by fire. Garbage and all organic refuse is best disposed of in this manner, especially in times of epidemics of communicable diseases. Cremation is the preferable method of disposing of the bodies of those dead of communicable diseases. In the sick-room it is well to destroy sputum by fire. Animal parasites in the soil and on trees are destroyed by burning petroleum on the ground or by gasoline torches.

Dry Heat. This agent lacks the penetrating power of moist heat, and is injurious to fabrics, rendering them brittle —though loss through the latter factor is somewhat obviated by not handling the articles until thoroughly cooled. All forms of life are destroyed by a temperature of 150° C. for one hour, a fact utilized in bacteriological laboratories and in the sterilizing rooms of surgical clinics by means of the hot-air sterilizer. Glassware, etc., is thus sterilized. The oven of a cook stove may be used in an emergency.

Boiling Water. This is an effective and easy method of disinfection and is available under most conditions. A temperature of 60° C. for twenty minutes will kill most of the non-spore-bearing bacteria, including those of pneumonia, erysipelas, plague, diphtheria, cholera, typhoid fever, and dysentery. Boiling immediately destroys them. Boiling water at

100° C. for an hour will destroy all life except a few spores. For that reason steam and not boiling water should be used in the sterilization of articles infected with tetanus or anthrax.

Boiling is particularly adapted to bed and body linen and all washable fabrics except woolens. As it fixes stains, fabrics stained with blood and excreta should first have the stains removed by soaking in cold water. Table ware, kitchen ware, urinals, and cuspidors, such surfaces as walls, floors, furniture, etc., can be thoroughly disinfected by mechanically cleansing with boiling water, to which may be added to advantage one of the chemical disinfectants. Organic and oily substances may be removed by boiling water containing strong alkaline soap, borax, or lye.

In sterilizing cutting instruments and bright steel objects 1 per cent. of carbonate of sodium should be added to the water to avoid rusting and injury to the sharp edges.

Steam. Steam is a quick, reliable, penetrating agent for both disinfection and sterilization, and is used to disinfect clothing, bedding, and most fabrics. Certain precautions are necessary to prevent the shrinking of woolens, and injuries such as staining and the running of colors in silks. It is not applicable to leather, furs, or skins, rubber shoes, oilcloth, or articles made of impure rubber, or wood or articles in whose manufacture glue or varnish has been used.

Special apparatus is not absolutely necessary for steam disinfection. Any closed space into which steam may be brought from a boiler may be utilized. The compartment need not be tight, as steam escaping through cracks establishes a circulation and promotes penetration.

Streaming steam, having the same temperature as boiling water, has the same disinfecting power, and requires half an hour to an hour for complete disinfection. Steam under pressure is much more effective. It has a temperature of about 120° C. under a pressure of 15 pounds to the square inch, and will sterilize thoroughly in twenty minutes.

Many effective apparatuses have been devised for steam disinfection by both methods. In all of them the air must be driven from the containing chamber, or dead spaces will be formed, due to the air being a poor conductor of heat. If this occurs, the steam is prevented from coming into direct contact with the objects to be disinfected, and the process will not be successful. The air is best driven out by admitting the steam from above, the descending vapor forcing the air out at the bottom. If the steam is admitted at the bottom, a nearly uniform mixture is formed with the contained air, which escapes with the steam, therefore a longer time is required to expel the air.

For disinfection by streaming steam the Arnold steam sterilizer is used in the laboratory and in physicians' offices.

Autoclaves or digestors are small forms of apparatus for disinfecting with steam under pressure. They are largely used for the sterilization of bacteriological and serological media and fluids.

The steam disinfecting chamber may be used with steam under pressure, with streaming steam, with formaldehyd gas without dry heat, and with combinations of the foregoing with or without a vacuum. It is most effective, and is extensively used not only for disinfection, but for the renovation of bedding and the treatment of clothing infested with lice.

The chambers are rectangular or cylindrical in shape, the latter being the stronger. In size they vary from small portable chambers mounted on wheels to large rooms for quarantine and municipal use. The chamber has an inner and an outer shell, thus forming a steam jacket which assures a uniform diffusion of heat in the chamber, and, by heating the contents of the chamber before the steam is admitted, the opportunity for condensation and wetting of the articles to be disinfected is lessened. After the process is finished and the chamber is opened, the heat from the steam jacket quickly dries the articles that have been steamed. Steam circulates

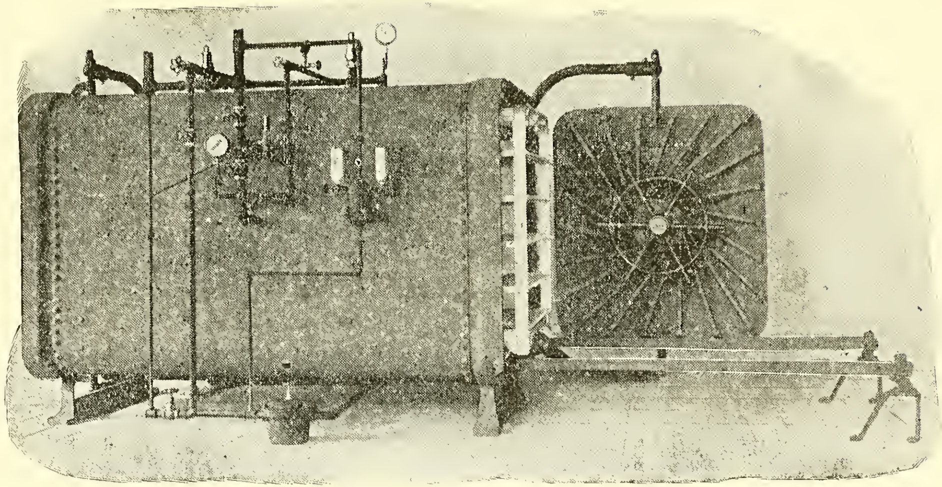


FIG. 23.—FULLY EQUIPPED STEAM DISINFECTOR. (*Courtesy American Sterilizer Company.*)

in the jacket during the entire process, being admitted from the main steam pipe to the bottom of the jacket, and thence can only be passed into the top of the chamber through circulating pipes. After circulating through the chamber it is allowed to pass out through the drip drain at the bottom. A non-conducting outside casing of asbestos or magnesia prevents the loss of heat. Chambers of the most approved pattern have a door at each end, allowing the introduction of infected articles at one end and their removal after disinfection at the other. The doors are usually secured by turnbuckles, and the joints between the doors and the chamber made tight by rubber gaskets. The doors should remain open when not in use, and the gaskets should be covered with graphite to prevent adhesion.

In the best chambers, after the articles have been introduced and the doors closed, a partial vacuum of about 20 inches may be created by means of a steam jet. The steam jet is preferable to a vacuum pump, as it is quicker in action. When a steam jet is not provided, the air can be driven out by turning on the steam and allowing the air to blow off through a valve for a few seconds at intervals. The creation of a partial vacuum shortens the time required to bring the infected articles to the required temperature and increases the penetrating power of the steam; there is also less tendency to condensation of the steam in the interior of the bundles and in the meshes of fabrics. After the expulsion of the air, steam under about 10 to 15 pounds' pressure is admitted very rapidly. After fifteen minutes' exposure a vacuum of 20 inches is again formed by the steam jet, the fresh-air inlet is opened, and a current of air passed through the chamber for about ten minutes. The articles are then removed and cooled, and the drying completed in a few minutes.

The disinfecting chamber must be provided with a thermometer to indicate the temperature in the interior. It is apt to be influenced by the heat of the jacket, and to give accurate readings it should be placed in the door. Mercurial and metallic thermometers that ring a bell by electric contact when a certain temperature is reached are now used. They may be placed anywhere within the chamber.

The articles which are undergoing disinfection are protected by copper or galvanized iron hoods from the dripping condensed steam. Gauges indicate steam pressure and vacuum pressure. The steam pressure from the boiler is controlled by a reducing valve in the main steam pipe, while a safety valve prevents over-pressure in the chamber.

In the operation of the large chambers the articles to be disinfected are placed in light-weight cars, provided with movable trays of galvanized iron and bronze hooks. The cars are passed into the receiving end and out of the discharging end. The large disinfecting plants have a dividing wall running across the building separating the receiving or "infected" end from the discharging or "disinfected" end. This is very necessary where a large amount of disinfecting for a variety of diseases is performed. It might appear to be a refinement in view of the comparatively slight importance of fomites in the dissemination of communicable diseases, but by this means a needless though slight risk is avoided. Both doors are never allowed to be open at the same time, and separate gangs of workmen operate the different ends.

If the packages of goods are packed too closely, the process will be unduly prolonged and may be untrustworthy, due to lack of penetration by the steam. Compressed bales of cotton, rags, etc., cannot be disinfected without being opened and the contents exposed.

Chemical Agents. Most chemical substances have, under varying conditions, some germicidal properties, but the number that may be employed to advantage as disinfectants is very small. Proprietary nostrums have been used during epidemics, the latter have terminated, and the chemicals have, without scientific basis, received credit, especially by the manufacturers, for checking the epidemic. We hear nothing of the other outbreaks in which the disinfectant or alleged disinfectant is employed, but in which the infection has nevertheless become diffused.

Some chemicals act upon certain varieties of organisms, but are powerless against others. Some will destroy all forms under some conditions, but will not affect slightly resisting bacteria protected by mucus or other matter. Again, substances may be deprived of their bactericidal power by chemical union with some other substance in or upon the matter to be disinfected.

The different disinfectants are most effective in various strengths. One may act best in 1 per cent solution, while another is most effective in 5 per cent strength. Some chemicals are ineffective above and below their optimum strength. In practical work, enough of the disinfectant must be used so that it will be present in the right proportion throughout the entire mass of material to be acted upon.

According to their mode of action chemical disinfectants may be described as follows:

A. *Reducing Agents.* 1. Sulphites. 2. Sulphur dioxide. 3. Ferrous salts.

Reducing agents lose their strength by absorption of the free oxygen of the air. They do not act on anaërobes.

B. *Oxidizing Agents.* 1. Chlorine. 2. Bromine. 3. Hypochlorites. 4. Peroxides. 5. Permanganates. 6. Ozone. 7. Commercial preparations depending on available chlorine.

Oxidizing agents are used for the disinfection of wounds, the purification of water, and the treatment of sewage.

C. *Absorbents and Deodorants.* 1. Sulphate of lime. 2. Slaked lime. 3. Quicklime.

D. *Those that Precipitate Albuminous Matter or Act by Their Toxic Power.* 1. The metallic salts, especially those of mercury, silver, zinc, and copper.

The chlorides contain the greater number of metallic ions, hence their higher efficiency. The salts are dissociated by solution in water and the ions become available for action on the bacteria.

E. *Those that by Chemical Combination with Albuminous Matter Form New Products that Resist Further Decomposition by Bacteria.* 1. Formaldehyde.

Many disinfectants combine two or more of the above qualities. A class of disinfectants, important for practical sanitary work, is obtained by the destructive distillation of tar. This class includes phenol, the cresols, etc., and commercial products containing them, with or without hydrocarbon oils. They form with water either clear solutions or emulsions. Their action is based either on precipitating albuminous matter or toxicity. This action is highest in phenol, and decreases as the H of the benzine ring is replaced by either methyl or hydroxyl groups.

The best commercial products are less toxic and corrosive than phenol or cresol. They form emulsions that have a cleansing effect like liquid soap. The higher efficiency of emulsifying disinfectants is due to the fact that the bacteria become practically surrounded by disinfectant in much greater concentration than exists throughout the liquid, due to Brownian movement of particles of the chemical.

Gaseous Disinfectants. An ideal gas, which is yet to be discovered, would be invaluable for sanitary work, especially terminal disinfection. The gaseous agents now available lack power of penetration, and can be depended upon for surface disinfection only.

Formaldehyde (Formic aldehyde, HCHO). A gas forming in water a neutral solution up to 40 per cent., though the commercial preparations are slightly acid in reaction, due to formic acid. It is obtained by the oxidation of methyl alcohol at a moderately high temperature. On a large scale it is generated by treating the alcohol in copper tubes containing incandescent coke.

Formaldehyde exists in three isomeric states: 1. As a colorless gas with slight odor and an irritating effect on mucous membranes. 2. Paraformaldehyde, or paraform, is a white substance, soluble in both water and alcohol. It is the result of the polymerization of formaldehyde and contains two molecules of the latter. 3. Trioxymethylene is a white powder consisting of three molecules of formaldehyde and having a strong odor of the gas.

The power of formaldehyde as a germicide is due to its property of combining directly with albumins comprising the protoplasm of the bacteria and forming entirely new compounds. To be effective, there must be direct contact between the gas and the germs. It is a true deodorizer, the obnoxious odors being destroyed by the formaldehyde forming new odorless chemical bodies with the nitrogenous products of fermentation and putrefaction.

Formalin, the commercial solution of formaldehyde, is supposed to contain 40 per cent. of the gas, though it is generally nearer 36 per cent. If the bottles are not well stoppered there is loss by volatilization. Cold causes deterioration by polymerization and precipitation of trioxymethylene.

Formaldehyde undoubtedly holds first place as a gaseous disinfectant. If it is used in sufficient concentration for a reasonable time under favorable conditions of temperature and moisture, it will destroy all pathogenic organisms. It will kill spores, but is not reliable for this purpose. Bacteria are killed more quickly when moist than when dry. Under laboratory conditions bacteria and spores are killed within an hour, but in practical work this time must be prolonged, as the gas diffuses slowly and the organisms are not always upon the surface of articles to be fumigated, being frequently incorporated in dust and albuminous matter, causing delay in the action of the gas. Formaldehyde is not poisonous to the higher animals, though it produces a severe irritation of the respiratory mucous membranes which may later cause death.

It is valueless as an insecticide. It sometimes kills mosquitoes, but insects with chitinous coverings, such as roaches and bedbugs, are unaffected.

Advantages. Formaldehyde is the best and safest gaseous disinfectant, and is a good deodorizer. It does not impair the tensile strength nor bleach silks, woolens, cottons, or linens. Colors, with the possible exception of aniline lavenders, are unchanged. Furs, leather, rubber goods, paintings, paper, photographs, woodwork, furniture, musical instruments, etc., may be exposed to the concentrated gas without damage. It is harmless to silver, steel, iron, nickel, brass, copper, zinc, and other metals.

Disadvantages. Formaldehyde is useful as a surface disinfectant only, as its powers of penetration are limited. Long exposure of large volumes of the gas is necessary to penetrate but a few layers of thin fabric, as it polymerizes in the meshes of fabrics and deposits as paraform on the surfaces. A portion of it is wasted by chemical union with the organic matter of woolens and other fabrics, which interferes with penetration. While harmless to fabrics, it is nevertheless not to be relied upon for their disinfection.

It may fix blood, pus, and fecal stains on clothing. It is quite costly. The odor is disagreeable and persistent, especially when much moisture is present. The odor may be overcome by thorough aëration, or it may be neutralized by ammonia water in the form of vapor or spray, or by exposure of ammonia in shallow dishes in the room.

Formalin is efficient when the temperature is above 50° F. and the air contains at least 60 per cent. of moisture, but is not efficient in cold, dry rooms. However, if the articles exposed are actually wet, penetration is prevented, and the solution of formalin so formed is too weak to be effective. The higher the temperature the surer the action of formaldehyde.

Application. The methods formerly employed involved the use of lamps, autoclaves, retorts, etc. These have largely given way to simple methods that dispense with all apparatus and evolve a large amount of gas in a short time. The rapidly rising price of permanganate of potassium may cause a return to some of the older methods.

The Permanganate-Formalin Method. When permanganate of potassium and formalin are brought together, heat, which liberates the formaldehyde gas, is rapidly evolved. For the best results 250 grams of permanganate and 500 c.c. of formalin should be used for each 1000 cubic feet of air space. The permanganate is placed in a suitable vessel and the formalin poured upon it. The reaction is violent, with much effervescence, therefore a deep pail or basin should be used to prevent bubbling over. In public health work buckets with flaring tops are employed. The vessel should be placed on a board or brick to protect the floor from heat.

The method yields about 81 per cent of the gas in the solution. About four-fifths of this is given off within five minutes, the remainder much more slowly in the following twelve hours. As the irritating gas is generated so quickly, arrangements must be made beforehand for the operator to leave the apartment immediately.

Paraform Lamps. For the disinfection of single rooms paraform lamps are useful. Paraform tablets may be burned in special lamps or in large tin cups, one ounce of paraform being sufficient for a space of 500 cubic feet. The lamp or alcohol flame under the receptacle must not be high enough to ignite the paraform, which burns readily, as when this occurs no formaldehyde gas is generated. Two ounces of paraform may be dissolved in 8 ounces of boiling water and then poured over 4 ounces of potassium permanganate in a 2-gallon pail.

New York Health Department Method. Paraformaldehyde 30 grams, potassium permanganate 75 grams, water 90 grams. Mix the chemicals in a deep quart pan, add the water and stir the mixture. To prevent fire and the soiling of the floor put the pan containing the mixture in a larger one. The gas is completely evolved in five to ten minutes, but is slow in starting. The quantities given in the formula are sufficient to disinfect 1000 cubic feet in four hours, and 87 per cent of the gas is evolved.

The Formalin-Lime and Aluminium Sulphate Method. This is slower, but quite as efficient as the permanganate method, and consists in the application of formalin to unslaked lime, the resulting heat liberating the formaldehyde. The lime should be in small pieces, freshly burned, and should slake rapidly in cold water. As given by Rosenau, the application of the method is as follows for 1000 cubic feet of space:

Solution A. Aluminium sulphate, 150 grams, dissolved in 300 c.c. hot water.

Solution B. Formalin, 600 c.c.

Unslaked lime, 2000 grams.

Mix solutions A and B and pour upon the lime, which is placed in a large bucket. The lime begins to slake in a few minutes and the gas is evolved.

The Spraying Method. This is applicable to small spaces such as drawers or closets. Formalin is sprayed upon the surface with some form of atomizer. The formalin acts directly, and the confined space is further disinfected by the evolution of the gas from the solution. Small rooms may be disinfected by sprinkling with formalin bed sheets hung in the middle of the room, one sheet of ordinary size being required for each 1000 cubic feet of space. Flower watering pots may be used to sprinkle the formalin on the sheets. A sheet will hold about 8 ounces without dripping. The room should remain closed for about eight hours.

Special Uses. Formaldehyde is especially adapted to the disinfection of rooms, spaces, etc., where an insecticide is not indicated. It is practically the only disinfectant that will not damage works of art and delicate objects of value, hence it can be used in richly furnished apartments, art galleries, museums, etc. It is the best germicide for routine terminal disinfection.

Sulphur Dioxide (SO_2). A colorless, heavy, irrespirable gas with a suffocating odor. It diffuses slowly and settles toward the floor, as its specific gravity is heavy compared with that of the air. It is produced by burning roll sulphur or "flowers" of sulphur, or by burning sulphur candles or carbon disulphide, the latter in a lamp. Its solution in water contains sulphurous acid, H_2SO_3. This acid is the actual disinfecting agent, as the dry gas is practically inert against bacteria, hence moisture is necessary in order to obtain any effective results. Sulphur dioxide may be condensed by pressure or cold into a clear liquid that is stable when sealed and kept from the air.

Advantages. Sulphur dioxide is cheap and readily procured, and several of the methods of use are easy to apply. It is a most efficient insecticide, and with or without moisture is rapidly destructive to all forms of vermin.

Disadvantages. In the presence of air and moisture sulphur dioxide is to some extent oxidized to sulphuric acid, H_2SO_4, which corrodes metals and other articles. It reduces organic matter and bleaches all colors of vegetable origin and many anilin dyes. It tarnishes most metals, including brass and silverware, gilt frames, etc. It weakens the tensile strength of cottons and linens. The disagreeable odor may persist for days or weeks, even after thorough aëration. It has very little power of penetration, and organisms must be freely exposed to be acted upon. It is not strong enough to kill spores. Under the most favorable conditions of humidity and temperature it is only indifferently effective.

Application. As the gas is generated slowly it is necessary to seal the room or space tightly, or much will be lost through cracks, crevices, etc. If used in spaces containing machinery, all metal parts should be coated with vaseline. Theoretically one-fifth of a pound of water should be vaporized for each pound of sulphur burned. Probably the evaporation of 2 quarts of water for each 4 pounds of sulphur consumed would secure the full disinfecting value of this agent without regard to the atmospheric humidity. The question of added moisture is more important in winter, when living apartments are closed and heated. In practical work 5 pounds of sulphur per 1000 cubic feet of air space are consumed. This usually gives full germicidal action.

Three methods of disinfection by sulphur dioxide are in use: 1. The pot method. 2. Sulphur furnace. 3. Liquid sulphur dioxide.

The Pot Method. This is the cheapest, easiest, and most effective method, and is best applied through the use of flat iron vessels (Dutch ovens) placed in pans or tubs of water, which not only serves as a precaution against fire, but protects the floor and, by vaporization, supplies the necessary moisture to hydrate the sulphur dioxide, without which there is no bactericidal action.

Flowers or rolls of sulphur, finely broken up or pulverized, should be used, and not more than 30 pounds should be placed in each pot. It is best lighted by alcohol or coal oil on a piece of waste. A little crater should be made in the sulphur, methyl or ethyl, alcohol or coal oil poured in and ignited, the melted sulphur forming a pool at the bottom of the crater. If the sulphur is in a heap the flame may go out. When hot, sulphur dioxide rises, but settles when cold. The pots of sulphur should be raised from the floor, as the cold sulphur dioxide, not supporting combustion, may smother the flame. For large spaces it is better to distribute a number of small pots about than to depend on one large one.

The Sulphur Furnace. Two forms of this apparatus are in general use. The sulphur-dioxide generated in the furnace is carried by means of hose or pipes to the spaces to be disinfected. In the Clayton furnace the gas passes through a series of tubes surrounded by water, and is pumped rapidly through small-caliber pipes without danger of fire or overheating. They are permanently installed on some ships for the destruction of rats and other vermin and for disinfection. They are useful as fire extinguishers. Portable furnaces are used for the destruction of vermin in sewers, stables, warehouses, etc.

In the Kinyon-Francis furnace the sulphur is burned in iron pans over fire boxes. Air is admitted through regulating valves and passes over the burning sulphur. The gas takes a circuitous route around baffle plates and angle irons to arrest sparks and to complete combustion, and is then blown through large distributing pipes by a fan. This method is expensive and requires heavy machinery, but by the expenditure of an excess of sulphur a somewhat larger percentage of sulphur dioxide may be obtained in a given space.

The pipes supplying the gas to a room or compartment should be led into the space as near the floor or deck as possible. In ships the pipes are admitted through hatchways, and should reach nearly to the bilge. The hot gas, ascending, gradually displaces the air. The opening should be closed when the gas freely escapes, indicating that the air has been forced out.

Liquid Sulphur Dioxide. This is a safe and efficient, but expensive, method of rapidly liberating a large volume of the gas. It avoids the danger of fire. Two pounds of liquid sulphur dioxide generate the same volume of gas as 1 pound of burning sulphur. Liquid sulphur dioxide is contained in tin cans or glass or metallic siphons. The cans are opened by cutting the lead pipes in the tops. The chemical is poured into a pot or bowl, where it rapidly volatilizes. The operator must act quickly and immediately leave the room. From the siphons the liquid sulphur dioxide is projected through some small opening into the room. As there is some drip and frozen substance as the result of expansion, this must be caught in a vessel on the inside. Moisture must be provided by a spray of water, pans of boiling water, or by injecting steam into the room.

Hydrocyanic Acid Gas (HCN). This gas is lighter than air, and has the odor of bitter almonds. It is generally made by the action of dilute sulphuric acid on potassium cyanide. It is highly toxic to all forms of life, and for this reason it is very little used as a disinfectant, but as an insecticide it is extensively employed. Its use is described in the section on "Insecticides."

Chlorine (Cl). Chlorine is a poisonous and destructive gas of uncertain germicidal power. Its use in the gaseous form as a disinfectant is not justified.

Liquid Disinfectants. In the practical application of liquid disinfectants several factors must be considered. Chemicals in emulsion have greater germicidal power than those in solution, but the latter have greater power of penetration. Thus it is of importance to break up masses when coal-tar derivatives are used in emulsion for the disinfection of feces.

Few disinfectants, even in strong, hot solutions, act instantly. The germs may be embedded in organic matter or covered with mucus that requires time for penetration by the chemical. When dry, time is consumed before the organisms become wet enough to be acted upon. The higher the temperature of the solution the more quickly it acts. In water even weak solutions act promptly, but if the organisms are in bouillon, filth, or other organic matter, strong solutions and long exposure are required.

If an alkaline chemical, such as lime, is used to disinfect an acid substance, enough of the chemical must be added not only to neutralize the medium, but to accomplish the disinfection.

When disinfecting chemicals are added to media with which they form precipitates, enough must be added first to form the precipitates and then complete the process.

The heavier the infection and the greater the number of organisms presumed to be present, the greater is the amount of disinfectant needed. The choice of disinfectants depends upon the resistance of the virus, and in a measure upon the nature of the substance to be disinfected. Some chemicals have a selective action upon certain organisms, for instance, mercury for *Treponema pallida*.

To be effective the object to be disinfected must be thoroughly wet with the solution, by immersion if possible. Walls, holds of ships, etc., may have the disinfectant applied through hose. The corrosive action of bichloride of mercury on steel, copper, and brass must be borne in mind when selecting a pump. It should be made of iron. Strong, hot solutions should be used, under pressure, if possible, to obtain the additional advantage of mechanical cleansing. The solutions may be applied with brooms or mops if pumps are not available. The method of applying solutions with an atomizer or nebulizer is not to be relied upon if the chemical is not volatile.

Bichloride of Mercury—*Mercuric Chloride*—*Corrosive Sublimate* ($HgCl_2$). A white, rather volatile, crystalline substance of heavy specific gravity. Made for commercial purposes by heating equal parts of dry sodium chloride with mercuric sulphate. Manganese dioxide is added to the mixture as an oxidizing agent to prevent the formation of mercurous chloride. Mercuric chloride is soluble in water, but more so in alcohol and ether. It is soluble in about fourteen parts of water at room temperature, but in two parts of boiling water. It is odorless, has a metallic taste, and is a violent corrosive poison. It is a germicide, but not a deodorant. Solutions, especially stock solutions, should be colored with some anilin stain for identification. Bichloride of mercury tablets and the bottles containing them should have some unusual shape.

Precipitation as an albuminate is prevented by the addition of about five parts of sulphuric, hydrochloric, or tartaric acid, or ten parts of sodium chloride for each 1000 parts of corrosive sublimate. Sea water, which contains about 4 per cent of salt, makes an excellent solvent for mercuric chloride.

Advantages. Bichloride of mercury kills both bacteria and their spores in relatively weak solutions. It is convenient and easily prepared, especially from tablets.

Disadvantages. It corrodes metals, therefore it must be kept in glass receptacles. Its action on lead pipes makes its use in water closets and plumbing undesirable. It is ineffective in alkaline media containing much organic matter, such as sputum and feces, because it precipitates albumen as the insoluble albuminate of mercury. It fixes blood and fecal stains on clothing. This may be largely avoided if the spots are washed out before the articles are immersed in the solution.

Application. Most non-spore-bearing bacteria are killed within fifteen minutes by a solution of 1-1000. It is necessary to use a solution of 1-500 and an exposure of not less than an hour for spores. Bichloride is used in much weaker solutions in surgery, even 1-10,000.

Special Uses. Corrosive sublimate finds its greatest usefulness in surgery and in personal prophylactic measures.

Phenol—Carbolic Acid (C_6H_5OH). Phenol is a corrosive poison with a strong, burning taste and a penetrating odor. The highest grade crystallizes in long colorless needles. Commercial carbolic acid is a crystalline mass containing cresols, zylol, and other higher homologens and tar oils. It turns reddish in time, and in contact with moist air deliquesces to a brownish liquid. The presence of the cresols gives the crude phenol a higher germicidal value than the pure product. Carbolic acid is one of the results of the dry distillation of coal tar, and is also made synthetically from benzol. It is soluble with difficulty in about fifteen parts of cold water. For ordinary use against non-spore-bearing bacteria solutions of 2.5 to 5 per cent are effective. The disinfecting power is increased by the addition of 0.5 per cent of hydrochloric acid. Its efficiency is increased by using warm solutions.

Advantages. Phenol does not actively coagulate albuminous matter. It is not injurious to fabrics, colors, wood, or metals in the standard strengths.

Disadvantages. It cannot be depended upon to kill spores. The work of McClintic and Ferry, demonstrating that carbolic acid and the cresols do not destroy the virulence of vaccine virus in 0.5 per cent solutions and five hours' exposure has thrown doubt on their effectiveness in smallpox and other diseases whose causes are unknown.

Application. Objects should be immersed for not less than an hour in a 3 to 5 per cent solution. Fabrics should be soaked for at least one hour.

Special Uses. It is well adapted to the disinfection of sputum, excreta, and other organic material. Crude carbolic acid may be used to disinfect the ground.

The Cresols. *Meta-cresol, Ortho-cresol, Para-cresol* (CH_4CH_3OH). These occur as impurities in crude carbolic acid, and are better germicides and less toxic to higher organisms than the pure acid. They are mixed with soap, tar, resin, dextrin, or gelatin to form many commercial preparations which may be diluted with water, some forming milky emulsions and some clear solutions.

Tricresol is a mixture of the three cresols freed from phenol, hydrocarbons, and water. It is a clear or pink, syrupy liquid and a good germicide in 1 per cent solution.

Creolin is a dark-brown, thick liquid containing about 10 per cent of cresols held in solution by resin soap. It forms a whitish, turbid solution with water. It goes under various trade names, and the results obtained are conflicting. A strength of 5 per cent is effective.

Lysol is a clear, brown, oily liquid containing about 50 per cent of cresols with neutral potash soap. It mixes freely with water, forming a clear, soapy, frothy liquid. It is effective in 1 per cent solution.

Liquor Cresolis Compositus, U.S.P., the official substitute for the commercial preparations, is a liquid soap containing 50 per cent of cresols. It is a thick, dark-brown liquid, making a clear solution in water. Its constituents are, cresol 500 grams, linseed oil 350 grams, potassium hydroxide 80 grams, water sufficient to make 1000 grams. It is used for the same purposes and in the same strength as trikresol.

Formalin. Formalin is a 40 per cent solution of formaldehyde in water. The solution is clear, and has the pungent odor of the gas. It is very irritating, but not very toxic. The solution is quite unstable, and much is lost by evaporation and polymerization.

Advantages. It is not injurious to copper, brass, nickel, or zinc; does not diminish the tensile strength or bleach the colors of fabrics.

Disadvantages. Hot formalin is injurious to iron and steel. It injures leathers, furs, and skins by union with their organic matter.

Application. A 10 per cent solution of the liquid containing the 40 per cent of formaldehyde has about the germicidal power of a 1-500 solution of corrosive sublimate. It is applied the same way as bichloride of mercury or carbolic acid, but is not used under conditions requiring great quantities of the disinfectant. In general disinfection work 5 per cent is theoretically strong enough, but if organic matter is present 10 per cent should be employed.

Special Uses. It is especially useful in the disinfection and deodorization of feces, the latter effect being almost instantaneous. A 10 per cent solution should be used and an hour allowed to complete the process. Formalin is also used in the disinfection of urine and sputum and in general disinfection practice.

Lime. *Calcium Oxide—Quicklime* (CaO). Procured by calcining marble, chalk, limestone or oyster shells. It is one of the alkaline earths. Water must be added to make it effective for disinfecting purposes. It is commonly employed as either lime or chlorinated lime.

Slaked lime, Ca(OH), calcium hydroxide, is a dry powder formed by adding half its weight of water to lime, calcium oxide (CaO). On exposure to the air it absorbs more water and also CO_2, and is converted into calcium carbonate, worthless for disinfecting purposes. It is essential that only freshly slaked lime be utilized.

Whitewash is slaked lime mixed with sufficient water and glue, or some other mordant, to promote adhesion. It is useful in destroying spore-free bacteria on the walls and ceilings of barracks, rooms, and especially cellars, barns, stables, poultry houses, and other rough structures. It is a good deodorant.

Milk of lime is slaked lime mixed with four volumes of water to the consistency of thick cream. It must be agitated before use, as the insoluble calcium hydrate settles to the bottom. Unless protected from the air the hydrate changes to the inert carbonate and the mixture is worthless.

Lime is a practical, cheap, and efficient disinfectant. It is useful in the disinfection of excreta. It must be well mixed with the mass, and sufficient must be used to make the mixture strongly alkaline. It is well to use an excess of the freshly prepared milk of lime and to allow the mixture to stand for at least two hours. Lime is used to advantage in the burial and disinfection of the bodies of those dying from communicable diseases. Twice the weight of the body of dry unslaked lime should be placed in the coffin. No water should be added.

Chlorinated lime, bleaching powder, or "chloride of lime," ($CaOCl_2$) is a combination of calcium chloride and hypochlorite. It is soft, white substance made by passing chloride gas through lime. Due to its deliquescent properties, it becomes moist and loses some of its chlorine when exposed to the atmosphere. The hypochlorites, upon which the efficiency of the chemical depends, become reduced to chlorides, which are not germicides. Chlorinated lime should contain not less than 35 per cent of available chlorine. It is a good disinfectant and deodorant. The latter property is due to its destructive action upon organic matter, its germicidal powers and its ability to combine with hydrogen sulphide and the volatile ammoniacal compounds of putrefaction. An excess of the substance should be used as the hypochlorites are reduced by organic matter.

Chlorinated lime is somewhat soluble in water and in alcohol. A 0.5 to 1 per cent watery solution destroys most microörganisms in from one to five minutes. A 5 per cent solution generally kills spores in less than one hour. Used as a dry powder chlorinated lime is a valuable desiccant and deodorant. When used as disinfectant for excreta, enough of the powder must be added to the mass to make a 4 or 5 per cent solution. The "American standard" solution contains 6 ounces of chlorinated lime to the gallon, and is in general use for the scrubbing of floors and the disinfection of excreta.

Chlorinated lime is useful in disinfecting the bath water, especially in cases of the fecal-borne diseases. Cisterns, tanks, wells, and springs can be disinfected with chlorinated lime.

Drinking-water may be disinfected as follows: Add 1 grain of chlorinated lime containing approximately 30 per cent of available chlorine to 1 liter of water. Mix thoroughly, and add enough to the suspicious water to make a 1-200,000 solution of chlorinated lime; agitate and allow to stand for twenty minutes. This will render safe water infected with the fecal-borne diseases, cholera, typhoid, and dysentery. (Rosenau.)

Antiformin consists of equal parts of liquor sodæ chlorinatæ (B.P.), and 15 per cent solution of caustic soda. In 2 to 5 per cent solutions it kills many pathogens in about five minutes, but has, however, very slight action on the acid-fast group, including the tubercle bacillus. It is a clear, alkaline solution with the odor of chlorine. It has deep powers of penetration, due to its solvent action on organic substances such as sputum, feces, pus, urinary sediment, etc., in which bacteria are found. The germicidal action of antiformin is due to the oxidizing properties of chlorinated lime. The waxy capsules of the acid-fast bacilli protect them.

Eusol is a clear solution containing 0.27 per cent hypochlorous acid. It is made by putting 12.5 grams of chlorinated lime in a Winchester quart flask, thoroughly shaking, adding 12.5 grams boric acid, and again shaking. The mixture is allowed to stand for a few hours and then filtered through cotton wool. The clear solution is eusol. It must be kept in tightly closed bottles. Eusol is successfully used in the treatment of gas gangrene wounds.

The Hypochlorites. LABARRAQUE'S SOLUTION — LIQUOR SODÆ CHLORATÆ (U.S.P.), is an aqueous solution of several chlorine compounds of sodium, chiefly NaClO and NaCl, and containing at least 2.6 per cent by weight of available chlorine. It is a clear, colorless solution when pure, but yellowish if an excess of chlorine is present. It has a faint odor of chlorine, and bleaches vegetable dyes. The solution is used in a dilution of 1-4, chiefly for the disinfection of the hands.

Dakin's Solution. A neutral solution containing about 0.5 per cent NaClO. It is the most widely used of the disinfectants of the chlorine group, and is employed in the Dakin-Carrel method of wound treatment. The solution is prepared with or without boric acid. The latter seems to have given the best results in the hands of those who have tested both. The following formulas are taken from Keen's "Treatment of War Wounds," and were given to Major Keen by Dr. Dakin:

"Neutral hypochlorite prepared with boric acid is best made as follows: One hundred and forty grams of dry sodium carbonate (NaCO), or 400 grams of the crystallized salt (washing soda), are dissolved in 12 liters of tap water, and 200 grams of chloride of lime (chlorinated lime) of good quality are added. The mixture is well shaken, and, after half an hour, the clear precipitate of calcium is filtered through a plug of cotton; 40 grams of boric acid are added to the clear filtrate, and the resulting solution is ready for use. A slight additional precipitate of calcium salts may slowly occur, but it is of no significance. The solution should not be kept longer than one week. *The boric acid must not be added to the mixture before filtering, but afterward.* The solution should be tested for neutrality by adding some of it to a pinch of solid phenolphthalein. If a red color, indicating free alkali, should develop, a little more boric acid must be added in order to remove it.

"Neutral hypochlorite prepared without boric acid is best made according to the formula given by Daufresne, and at the present time is perhaps more generally used than any of the other modifications.

"Two hundred grams of good bleaching powder are put in a 12-liter bottle with 5 liters of tap water. The solution is shaken vigorously and allowed to stand for at least six hours, unless a mechanical shaker is used, when half an hour's shaking will be found sufficient. In another vessel 100 grams of dry sodium bicarbonate and 80 grams of sodium bicarbonate are dissolved in 5 liters of cold water and then added to the bleaching powder mixture. The whole is shaken vigorously for a few minutes, and the precipitate allowed to settle. At the end of half an hour the clear solution is siphoned out and then filtered through paper. The proportions given above for the carbonate and the bicarbonate of soda are those given by Daufresne. It is our experience, however, that with most brands of American bleaching powder it is better to use 90 grams of each salt. This solution must invariably be tested for neutrality by adding a pinch of solid phenolphthalein to a little of the solution. If the solution should react alkaline, one of three methods must be employed to correct it, otherwise skin irritation will surely result.

"(*a*) Pass carbon dioxide gas into the solution until a sample shows no alkalinity when tested as described. This is perhaps the best method.

"(*b*) A neutral hypochlorite may be secured by reducing the proportion of carbonate of soda and increasing the bicarbonate.

"(*c*) Boric acid may be added until neutrality is secured.

"An advantage of the carbonate-bicarbonate preparation is that it possesses greater stability and can be kept for several weeks without much deterioration. On the other hand, with varying qualities of bleaching powder, containing different amounts of free lime, it is more difficult to adjust the proportions so as to obtain a neutral solution directly. Probably those having adequate laboratory facilities will prefer the carbonate-bicarbonate solution, while the mixture containing boric acid is readily made under less favorable circumstances."

The fluid is an ideal isotonic wound antiseptic of high bactericidal and low toxic or irritating quality, in which it differs from Labarraque's solution. It does not injure the living tissues.

Permanganate of Potassium ($K_2Mn_2O_8$). A strong germicide, but of limited practical use because of its instability in the presence of organic matter and its property of staining. It is a purple, crystalline substance with an astringent taste, soluble in sixteen parts of cold water and two parts of hot water. The purple tint is changed to brown by oxidization of organic matter and oxidizing agents. Potassium stain on the skin may be removed by a solution of oxalic acid, hydrochloric acid, or lemon juice. Its disinfecting power is due to the nascent oxygen liberated on oxidization. A 5 per cent solution will kill spores in twenty-four hours.

Permanganate of potassium is chiefly used in surgery, but has a limited range of usefulness in the purification of water.

Iodine. A powerful disinfectant, superior to bichloride of mercury. It does not coagulate albumen, and in effective strengths is non-toxic and non-irritating, and is well suited to surgical practice. The tincture is an excellent means of sterilizing dirty wounds and the skin before incision.

Sulphate of Copper (SO_4). This chemical is about half as strong as $HgCl_2$, and its use as a disinfectant is quite limited. In the strength of 1-1,000,000 it has considerable value in the destruction of many species of algæ that cause unpleasant smells in public water supplies. In 1-400,000 it will kill typhoid bacilli in water that does not contain an excessive amount of organic matter.

Ferrous Sulphate ($FeSO_4$). This is a cheap, but untrustworthy, deodorant. Its value as a disinfectant is almost *nil*.

Acids. The mineral acids all possess germicidal power, but, with the exception of hypochlorous acid, their use as disinfectants is impracticable, as they corrode the common metals and impair the tensile strength of fabrics. Hypochlorous acid solution produced from hypertonic saline and Eupad, a powder, and Eusol, a solution, are used in surgery. Boric acid kills the less resistant bacteria in 2 per cent solution and inhibits the growth of others. The organic acids—acetic, citric, malic, formic, and salicylic—are less corrosive and less germicidal than the mineral acids.

The Essential Oils. These have some, but not very strong, germicidal powers. Those in general use are the oils of peppermint, eucalyptus, and thyme. They contain as the valuable active principle, menthol, eucalyptol, and thymol respectively. They are too expensive for use other than in antiseptics intended for application to mucous membranes.

Soaps. Most soaps have a limited disinfecting power, but their chief value is as detergents. The common soaps are apt to contain rosin instead of fat, and many of the soft soaps are made from impure fats and alkalies. Hard water and low temperatures decrease the effectiveness of soap. As auxiliaries to mechanical cleansing and in conjunction with compatible chemicals, such as lye and carbonate of sodium, they are most useful. Soap solutions should be hot and strong and made if possible with soft water and applied with brushes or mops.

Most medicated soaps are highly odoriferous compounds of little or no value as disinfectants or antiseptics. The double iodide of mercury has been incorporated in soap in the proportion of 0.5 to 2.0 per cent and remains unchanged. In a 1 per cent solution this soap kills pus cocci, cholera spirilla, and diphtheria and typhoid bacilli in one minute. It does not precipitate albumen, and does not attack steel, nickel, silver, aluminium, or lead.

Bedside Disinfection or Medical Asepsis. The nearer the fountainhead of infection the sanitarian strikes the greater the certainty that the infection will not spread. The bedside of the patient is the place where disinfection can be most effectively performed and it is there that the excretions from the mouth, nose, bowels, and urinary tract should receive the most careful attention as soon as secured. When bedside disinfection is properly performed there is no danger of general dissemination of the disease.

The process includes not only disinfection of the excretions, but of thermometers, tongue depressors, dishes, and other utensils, soiled floors, clothing, and bedding, the persons of all coming in contact with the patient, particularly the hands of the nurse and physician, and all surfaces infected or likely to be infected by excreta.

If opportunity is afforded, all unnecessary furniture, hangings, etc., should be removed from the room to be occupied by a patient suffering from a communicable disease, as this simplifies the final treatment of the apartment and its contents. Unless greater comfort in the matter of ventilation, etc., is gained, patients should not be transferred after the development of the disease. The danger from such fomites as furniture is largely theoretical. The floor or carpet about the patient's bed may be contaminated with discharges, as the result of carelessness in not providing some form of covering for them, or a receptacle for the discharges.

The patient, especially in a case of one of the acute exanthemata, should, if possible, be placed in a room that can be isolated from the rest of the house. It is highly desirable that disinfectants and facilities for boiling water for prompt bedside disinfection of infective discharges, contaminated linen, etc., be kept near at hand. Admission should be denied to all whose presence is unnecessary. Attendants should wear only smooth-surface and washable dresses. No used body or bed linen should be removed from the sick-room until after treatment with disinfectant solutions, nor should food be taken away to be eaten by others. No discharges should be finally disposed of until they have been thoroughly disinfected. If the broom is used, the dust should be controlled by the use of wet bits of paper, tea leaves, or sawdust, which should be disinfected and burned with the dust. Surfaces generally "dusted" should be wiped with cloths moist with some disinfectant. The cloths should afterward be immersed in the disinfectant solution or boiled. The room must have the proper protection against flies and mosquitoes, especially in cases of the mosquito-borne diseases.

It is a waste of time, energy, and money to attempt to disinfect the air of a sick-room while occupied. Placing such high-smelling substances as formalin, carbolic acid, and chlorinated lime in pans about the room is absolutely futile. The same is true of hanging sheets wet with antiseptic solutions in doorways. At times deodorants such as formalin are indicated, but this should be rarely necessary if proper cleanliness and ventilation have been secured.

If a room is badly infected, particularly with tuberculosis, in which there is danger of infection through dust, it should be disinfected with formaldehyde as a protection to those who remove the carpet, bedding, etc., for further disinfection.

Sunlight, when available, and through and through ventilation at all times, are most important in killing and diluting any infection of the air. An open fireplace aids in the purification of the air of sick-rooms by improving ventilation.

The nature of the disease has much to do with the disinfection required, the avenues of exit of the infectious agents indicating the discharges to be treated. In diseases affecting the respiratory tract (diphtheria, pertussis, pulmonary tuberculosis, pneumonia) the nasal discharges and sputum contain the causative organisms; the feces contain those of typhoid fever, cholera, dysentery, and tuberculosis of the intestines; the urine the typhoid bacilli in typhoid fever, and the desquamating epithelium in variola and scarlatina presumably contains the specific viruses of those diseases.

Feces. Bowel discharges may be disinfected with formalin, phenol, the cresols, lime, chlorinated lime, or boiling water. The last is highly effective, but only accomplished to advantage in hospitals having appropriate apparatus in which the feces may be boiled or steamed without generating offensive odors.

The excreta should be received in a vessel containing an amount of disinfectant solution at least equal to the probable volume of the discharges. The mass should be thoroughly mixed and allowed to stand at least one hour before being disposed of and the vessel cleansed and disinfected. Feces should always be protected from flies and other insects, even while mixed with disinfecting solutions.

Formalin in 10 per cent solution is a very satisfactory disinfectant for feces, as it also acts as a deodorant.

Phenol in 5 per cent strength is effective in one to two hours, but its odor is sometimes objectionable.

The cresols act quickly and efficiently, as they do not precipitate albuminous matter. If emulsions are used, great care must be exercised in mixing the mass, as they lack powers of penetration.

Milk of lime is used in the strength of one part by weight of freshly slaked lime to four parts of water. The mixture must be alkaline in reaction. If lime is used in water-closets, a thick mass will accumulate and obstruct the pipes.

Chlorinated lime is a very serviceable disinfectant for feces. A full strength of 3 per cent and an excessive amount should be used as in the presence of air chlorinated lime is rendered inert by organic matter.

Dry earth delays putrefaction by acting as a desiccant. It is a good deodorant.

Urine. Formalin, one-twentieth of the volume of the urine, is the best disinfectant. Equal volumes of 5 per cent solution of chlorinated lime, carbolic acid, or one of the cresols are effective.

Sputum and Nasal Discharges. Sputum is a difficult material to disinfect, and both it and nasal discharges are best received in pieces of gauze, paper spit-cups, or paper napkins, and burned. Receptacles receiving sputum should contain a disinfectant solution or water and be kept covered. If chemical disinfection is depended upon, phenol 5 per cent, chlorinated lime 3 per cent or formalin 10 per cent should be used.

The Person. It is assumed that intelligent nursing embodies the proper care and cleanliness of the patient. The danger of infection in measles and scarlatina is largely during the early stages, through secretions from the respiratory mucous membranes; nevertheless, the period of desquamation should receive attention. The patient should be frequently cleansed and scrubbed with warm water and soap to remove the dead epithelium. The use of antiseptics is unnecessary. The patient may receive his final bath and fresh clothing in his apartment; removal to another room is unnecessary.

The hands of those nursing the communicable diseases are unavoidably soiled and infected, and must be immediately and thoroughly washed, though not sterilized in a surgical sense, after every act by which they may become infected.

These include handling the patient's body and the bed pan, and wiping away discharges. Soap-and-water washing with mechanical cleansing of the hands every time they become infected is ordinarily enough. If supplementary treatment seems indicated, phenol 5 per cent or one of the cresols may be used. Formaldehyde 3 per cent and corrosive sublimate 1-1000 are efficient, but the former will harden the skin and the latter may cause a dermatitis if their use is persisted in.

The practice of nurses, physicians, and visitors wearing a gown or sheet over the clothing while in a room occupied by a communicable disease case is commendable, though unnecessary, unless actually handling the case. It is a safeguard against carelessness. A cap is unnecessary.

Screens of washable material attached to the beds or arranged between the beds to avoid dissemination of infectious oral and nasal secretions by "droplets" in coughing, sneezing, snoring, etc., have proven entirely satisfactory, and are to be highly commended.

Bed Linen and Clothing. The bed linen and body linen worn by patients during illness with communicable diseases should, of course, be frequently changed and disinfected. Towels, sheets, pillowslips, handkerchiefs, napkins, etc., easily become infected, and should invariably be disinfected after contact with any of the communicable diseases except the insect-borne diseases. This may be accomplished by steam, boiling, or by soaking in phenol or one of the cresols 5 per cent, formalin 10 per cent, bichloride of mercury 1-1000. The articles should be immersed at least an hour in the solutions, if not obviously soiled. If infection and contamination are obviously present or suspected, the further precaution of boiling should be added. Soiled linen should be conveyed from the sick-room to the laundry in sheets or sacks moistened with a germicidal solution.

Fabrics soiled with pus, blood, or excreta require special care. The sheet or sack containing them may be placed unopened in a 3 per cent solution of soft soap and heated to 50° C. for three hours, and left in the same solution for forty-eight hours after it cools. (Rosenau.) Corrosive sublimate should not be used on fabrics stained with albuminous matter, as the chemical acts as a mordant, making the stain permanent. The same is true of heating or boiling without a preparatory cleansing with soap and water.

Dishes, Utensils, etc. All dishes, tableware, and utensils coming in contact with patients should be disinfected by scalding water, if possible, before being taken out of the sick-room. The remains of all meals should be destroyed.

Thermometers. When not in use, thermometers should be kept in a strong bichloride of mercury or formalin solution. After use they should be cleansed with soap and water or alcohol.

Tongue Depressors. Wooden tongue depressors that may be destroyed by fire are to be preferred. If metal ones are used they should be disinfected with boiling water.

Terminal Disinfection. It is folly to attempt the disinfection of a room or its contents until after the removal of the patient. Much alleged room disinfection has been in the past—and some still is, because of lack of thoroughness—worse than useless. It creates an undeserved sense of security. Even with the greatest care and most intelligent application the results with modern improved processes are far from perfect. If terminal disinfection is indicated in a room, it is probable that adjoining rooms, connecting hallways, and possibly distant parts of the house are also infected and require the same treatment. Material carried by air currents (if such exist) passes through doorways which are supposed to be "protected" by sheets. Germs are carried by members of the family, attendants, visitors, and the patient himself to distant parts of the house.

The method of treating walls, floors, furniture, clothing, etc., by spraying is slow and inefficient if a non-volatile chemical is used. It requires other treatment, and is not without danger of mercurial poisoning if bichloride of mercury is used.

When gaseous disinfection is practiced the preparation of the space to be disinfected is important. Move the heavy furniture away from the walls, open all drawers and closet doors, lids of trunks, etc., to allow free diffusion of the gas. Bedding, clothing, and all fabrics should be suspended freely from lines or clothes horses, and the pockets of clothing turned inside out. It is necessary that the same surfaces exposed to the infection be exposed to the gas. Cracks and crevices should be closed by adhesive paper or calked with wet cotton, putty, or some other suitable material. Loosely fitting window sashes may be secured by wooden wedges and the cracks calked. Paste stout paper over registers and ventilators. Seal the doors and openings for drafts of stoves. Completely close the flue outlets of open fireplaces and Franklin stoves. Search for openings in unusual places. This work should be carefully done, as much gas is lost through leaks by diffusion and by absorption. Practical conditions differ so widely from laboratory results that a liberal allowance of gas must be made for the inevitable waste due to wind pressure, diffusion, etc.

Formaldehyde is as near the ideal gaseous disinfectant as we possess. However, its penetrating powers are so limited that any article badly infected must be treated by some other method. For rooms presumed to be infected with the organisms of bacterial diseases, formaldehyde is the best routine disinfectant.

After proper preparation of the room the gas is generated by the desired method. The room should be sealed so that it cannot be opened without the knowledge of the disinfector, and should be opened by him only after the completion of the process. The room should be exposed to the gas overnight, or, if the disinfection is started in the morning, through the day. On opening there should be a distinct odor of the gas. This is dispelled by ammonia and free aeration. In homes where the people have no other accommodations available the rapid neutralizing of the gas by ammonia is important.

The application of the preceding measures will accomplish the gaseous disinfection of a room, but the process should be supplemented by thorough mechanical cleansing, sunning, and airing.

Carpets, rugs, hangings, etc., should not be removed until after the preliminary gaseous disinfection. They should then be sent to a sterilizing plant for steam disinfection, followed by vacuum cleaning and sunning. Upholstery, carpets, rugs, etc., that have been grossly contaminated by discharges or other means should have a strong solution of formalin applied to the polluted spots. Trash that has accumulated in the room should be burned.

Many articles such as mattresses, upholstered furniture, cuspidors, etc., require special treatment. Mattresses, especially if polluted by excreta and urine, must be sterilized with steam. Those filled with excelsior, straw, or corn husks, should have the contents removed and burned, and the ticking immersed in a disinfectant solution and boiled. Furniture upholstered with woven fabrics should be well beaten and exposed to the air and sunlight. Leather upholstery should be wiped, especially in the crevices, with cloths wrung out in diluted formalin or corrosive sublimate. Cuspidors are best disinfected by boiling or with steam.

Water-closets. The bowls are best disinfected with 5 per cent solution of the cresols or dilute formalin. Woodwork, such as the seats, should be treated with the same chemicals. Corrosive sublimate, by its action on lead, damages plumbing, and should not be used.

Wells and Cisterns. Half a barrel of freshly burnt lime is thrown into the water, well stirred, and the walls scoured with the milk of lime so formed. The well is then emptied and the process repeated, the milk of lime being allowed to remain in the well twenty-four hours. It is then well stirred, pumped out, and allowed to refill, and again emptied, repeating this process until but a trace of lime remains in the water. Chlorinated lime may be used in sufficient quantity to make about a 1 per cent solution.

Stables. Stables are disinfected for tuberculosis, glanders, anthrax, pleuropneumonia, tetanus, and various communicable diseases of man. The abundance of organic filth which works its way into crevices and saturates woodwork, and the occasional presence of the spores of anthrax and tetanus, make the thorough disinfection of stables very difficult. A preliminary fumigation with sulphur, to destroy vermin and surface infection, and as a protection to the disinfecting squad is desirable.

All hay, straw, grain, etc., should be removed and destroyed by fire.

The blankets should be burned if of little value; otherwise, they should be wrapped in sheets moist with bichloride of mercury solution and boiled or steamed.

Tools and equipment such as buckets, brushes, curry combs, etc., that have been in contact with sick animals or infectious material, should be mechanically cleaned with a hot phenol solution, in which they may be immersed for some hours. Wooden and metallic articles should be scoured with a brush and hot water and soap, followed by soaking in 5 per cent carbolic acid solution or one of the cresols. Harness, saddles, etc., after a thorough cleansing, should be scrubbed with a strong solution of corrosive sublimate or phenol.

Thoroughly saturate with a hose or mop the walls, floors, ceilings, stalls, corners, and all parts of the stable with a strong solution of carbolic acid or one of the cresols. Scrape out and burn the dirt from the cracks and crevices. Cleanse the woodwork with a strong, hot solution of alkaline soap or lye. Follow this with another general sousing with the disinfectant solution. The stable should be aired for some days and the interior then whitewashed.

The water remaining in watering troughs should be disinfected with a reliable disinfectant. The troughs must be mechanically cleansed inside and out, as they are apt to contain organic matter. Follow this by disinfection with a strong germicide, preferably carbolic acid, one of the cresols, or formalin. This is very important if the disinfection is for glanders. Before use, flush the troughs with water to avoid the danger of poisoning the animals. The drains and plumbing pipes should be disinfected by pouring strong solutions of formalin, chlorinated lime, or phenol through them.

If it is desirable to disinfect the ground surrounding the stable it may be done with lime.

Railroad Cars. As a routine prophylactic measure formaldehyde disinfection, followed by mechanical cleansing, is sufficient for parlor cars and day coaches. All woven articles, such as carpets, rugs, upholstered seats and backrests should, if possible, be removed from the car, cleansed by the vacuum process, and sunned for several hours. The floors should be scrubbed with a suitable disinfectant solution. The cuspidors should be disinfected with hot carbolic solution and the contents treated in an appropriate manner. If the car is known to be infected, the disinfecting process is the same as that for a room.

Railroad cars are frequently infested with the disease-carrying insects, especially flies and mosquitoes, and sometimes bedbugs. It is difficult to keep them out of the cars, but precautions must be taken on trains leaving areas infected with yellow fever, malaria, plague, and typhus. If insects succeed in obtaining entrance, they must be destroyed if possible. At times it is necessary for the passengers to change cars upon entering a non-infected district.

The berths of sleeping cars, not being accessible to the sunshine and fresh air, may harbor such infectious organisms as resist desiccation for long periods of time. The construction, ornamentation, compact storage spaces, etc., of sleepers make their disinfection difficult.

The preparation of any passenger car for gaseous disinfection includes the closing of water-closet hoppers, ventilating ducts for fresh air, and the ventilator openings for the Pintsch gas flames. All the berths must be open, and bedding, curtains, etc., removed for disinfection by other means.

Formaldehyde gas or hydrocyanic acid gas is suitable. The latter should be used if the car is infested with bedbugs or other vermin.

The washbasins and slabs, dental basins, seat of the water closet, brushes, combs, and other articles used by the passengers should be disinfected with an appropriate germicidal solution.

The disinfection of cattle cars and other cars, freight and express, used to transport animals is important, especially if infection by anthrax, tuberculosis, tetanus, or foot-and-mouth disease is known or suspected. The process is the same as that of disinfection of stables.

Exposure to the weather generally keeps open cars biologically clean. They are easily disinfected by scrubbing with a germicidal solution.

Freight cars may be disinfected by steam from a locomotive. They seldom require disinfection or fumigation, but the latter, preferably with sulphur dioxide, is sometimes necessary for mosquitoes, fleas, rats, or mice.

Disinfection of Ships. The same principles that guide the sanitarian in disinfecting a house guide him in disinfecting a ship, but the peculiarities of naval construction and maritime conditions require ingenuity in applying them. The same methods are now used in disinfecting both wooden and iron ships, as we now know that few, if any, pathogenic bacteria lodge in the cracks, open joints, and other crevices so common on wooden ships.

It is very seldom that a ship requires disinfection in all its compartments. Modern methods of medical asepsis enable us to limit the presumably infected area on a ship as in a building. It is well, however, to err on the side of safety, and make assurance doubly sure by carrying the prophylactic measures to excess. A careful inspection of the ship will disclose the feeding and breeding places of vermin and such dirt, moisture, and other conditions favoring bacterial growth and virulence as may be present.

Merchant ships, especially tramp steamers and sailing vessels, are apt to be filthy and vermin infested. In view of this, a thorough mechanical cleansing of all parts of the ship requiring it should be a preliminary measure to disinfection.

Most bacterial infections require the same general methods of treatment, but special procedures are indicated in certain diseases. In cholera and the other fecal-borne diseases the water and food supply require the greatest attention; if plague has occurred, the rats and fleas must be exterminated; for yellow fever and malaria efforts must be concentrated against the mosquito; for typhus the louse must be eradicated; smallpox and the other exanthemata indicate vaccination and the disinfection of living compartments, clothing, bedding, etc.

The disinfection of a ship of any size can be accomplished to advantage only at a well-equipped quarantine station. The vessel should be moored alongside the dock or barge containing the disinfecting plant before operations are begun.

The employees of quarantine stations must wear appropriate working clothes, and it is desirable that they be immume to the disease in question.

The passengers and all the crew except those necessary for the safety of the ship and those who are needed in the work of disinfection, are landed at the quarantine station. The warrant and petty officers, including the boatswains, carpenters, and quartermasters, are useful at such times on account of their intimate knowledge of the ship and their sense of responsibility in carrying out orders. The effects of the personnel are then removed and disinfected, but are not returned to the ship until after the disinfection of the latter is completed.

Fabrics such as bedding, hangings, and floor runners are removed and disinfected in steam chambers. Precautions must be taken on passenger steamers, especially, to obtain all the used and soiled linen kept in the dirty linen lockers in the custody of one of the stewards.

Following the removal of all portable objects requiring disinfection by special processes the disinfection of the ship itself is in order. Dirty compartments must have a preliminary mechanical cleansing, preferably with a lye solution and scrub brush. The principal disinfectants used are sulphur dioxide gas, formaldehyde gas, hydrocyanic acid gas, and solutions of bichloride of mercury and carbolic acid.

The cabins, saloons, and similar compartments of liners usually contain metal and bright work which is tarnished by bichloride and sulphur, therefore it is better that they should be disinfected with formaldehyde gas, or solutions of formalin or carbolic acid. When sulphur is used, metal surfaces and gilt decorations should be protected by a coating of vaseline. The forecastle and steerage may be disinfected with sulphur or bichloride, but formaldehyde is generally to be preferred. Special attention must be directed to the sick bay, or any space such as the steerage, in which patients were cared for and which may be presumed to contain the infection. The hold seldom requires disinfection for bacterial infections, but does require special attention in fumigation to clear the ship of rats. Holds may be fumigated with sulphur dioxide or hydrocyanic acid gas, or may be disinfected with a solution of bichloride of mercury applied with a hose. The water-closets should be disinfected with chlorinated lime or carbolic acid, and thoroughly cleansed and flushed with water. In old sailing vessels the forepeak must be disinfected in like manner. Certain spaces and compartments aboard ship such as the engine and boiler rooms, carpenter shop, paint locker, sail locker, chain locker, lamp room, pilot house, and the machinery spaces are rarely infected and seldom require disinfection. The compartments of iron steamers usually have steam pipes for use in case of fire. These may be used to disinfect the compartments provided they are above the water line. Clothing and other fabrics may be exposed in these steam-filled compartments and thus disinfected.

The ship's drinking-water supply in water tanks or casks may be infected with the water-borne infections, cholera, typhoid fever, or dysentery, or infested with the larvæ of disease-bearing mosquitoes. The water may be disinfected in the tanks or casks by the addition of sufficient chlorinated lime to make a 1 per cent solution. After standing twenty-four hours it should be pumped out. Sometimes the water may be boiled in the tanks by leading steam hose into them. The water casks that have become the breeding places of mosquitoes should be emptied and cleansed. The water containing the larvæ may safely be spilled overboard into salt water, as neither Anopheles nor Stegomyia develop in salt water. If the ship is in fresh water petroleum or some other larvacide must be used before the casks are emptied overboard.

The cargo of an infected ship seldom requires disinfection because, as a rule, the cargo hatches are kept well battened down during the voyage, and there is little or no communication with the source of infection. The disinfection of such articles as rags, household goods, second-hand articles or food products from infected places may be indicated. New merchandise or manufactured goods seldom carry infection. The disinfection of the cargo on plague-infected ships is the one exception to the rule.

Two kinds of ballast are utilized by ships: (1) water, (2) solid. Modern vessels use water ballast. The tanks may have been filled from a river, fresh-water lake or other source infected with cholera, typhoid, or dysentery. This should be pumped out and filled with salt water while at sea; if it has not been done, upon arrival at a quarantine station from an infected port the vessel is required to return to the open sea, empty the tanks, and refill them with sea water. The suspicious water should be treated with chlorinated lime before it is pumped out.

Solid ballast consisting of clean, hard rock or beach sand is not likely to carry infection of any kind, and usually requires no attention. Rubbish and street sweepings sometimes carried as ballast is open to suspicion if it comes from an infected port. It should never under any circumstances be unloaded on the city water front.

Sulphur gas is a valuable and efficient disinfectant and is invaluable as a fumigant in destroying rodents and insects. It is generated by burning sulphur, 5 pounds per 1000 cubic feet of air space or liberated from 10 pounds of liquid sulphur dioxide. Sufficient moisture is supplied by steam or water, and the time of exposure is twenty-four hours in metal ships and forty-eight to seventy-two hours in wooden ships. When the cargo cannot be removed, the sulphur gas should be generated in a special furnace to minimize fire risk. When the hold is fumigated by burning sulphur in iron pots set in pans of water, the pots should be placed in an elevated position either on piles of ballast or on the 'tween decks. When the sulphur fumes are led into the hold from a sulphur furnace, the pipes should be led down the hatchway toward the bottom of the hold, so that the compartment may be filled with the fumes from the bottom, displacing the air above. For this reason, one or two ventilators or part of a hatch should be left open for the escape of the air. After the gas has begun to escape in some quantity the openings are tightly closed.

The amount of sulphur to be used is computed from the tonnage of the vessel. It is assumed that the net tonnage of the vessel indicates the cubic measurement of her cargo-carrying capacity, and that 10 net tons represent 1000 cubic feet of space.

Hydrocyanic acid gas is more toxic and more diffusive than sulphur dioxide and therefore more efficient. With it a loaded ship may be fumigated in an hour, without injury to the most delicate fabrics or perishable fruits or vegetables. Five ounces of potassium cyanide per 1000 cubic feet of air space are sufficient for the destruction of rodents and insects.

Bichloride of mercury solution 1-1000 is the most suitable solution for the treatment of decks, bulkheads, etc. It may be applied with a force pump or by means of mops and buckets. When applying it with a hose, begin at one end of the deck ceiling and systematically flood the entire surface, coming down the walls and flooding the deck last.

The disinfection of large ships should be systematically carried out. The work should begin forward with the forecastle and progress aft, first on the starboard and then on the port side. Every compartment and room must be unlocked and entered, and the officer in charge of the work must assure himself by personal inspection of the contents and uses of each room.

When fumigating and disinfecting vessels for plague, yellow fever, and other insect- and animal-borne diseases, the fumigation must precede everything else in order to insure the destruction of mosquitoes, rats, and other vermin, and the fumigation must be simultaneous in all parts of the vessel. Special compartments and rooms may receive individual treatment if indicated.

CHAPTER VI

INSECTICIDES

Gaseous agents are the most practical insecticides. Sulphur dioxide, hydrocyanic acid gas, carbon bisulphide, and carbon tetrachloride are most frequently employed.

The space to be treated should be even more carefully prepared than for disinfection. Insect and mammalian vermin seek protection in folded clothes, remote corners, etc., but are attracted toward a light as a means of escape from the gas. In view of this the room to be fumigated should be darkened except one source of light, about which the dead vermin will be found. The closing of all openings such as ventilators, fireplaces, registers, and cracks and crevices should be carried out as described for gaseous disinfection. The same precautions apply to the arrangement of the furniture and the protection of the contents of the room, especially fabrics, paintings, metallic articles and instruments, particularly if sulphur is employed.

Sulphur. Sulphur is the most practical insecticide. It is used in the gaseous form or as the powdered flowers of sulphur. It acts as a general protoplasmic poison.

Advantages. Sulphur dioxide kills all kinds of vermin, mosquitoes, flies, the more resistant forms of insect life, such as fleas, roaches, bedbugs and ticks, and also rats and mice. The dry gas is just as toxic as the moist sulphur dioxide, but has no germicidal action, as this is due to sulphurous and sulphuric acids generated in the presence of moisture. The dry gas does not tarnish metals nor bleach nor rot fabrics. As an insecticide it has strong powers of penetration. Diluted proportions will reach and kill mosquitoes through several layers of fabric. The powdered form in dips and ointments kills ticks and the itch mite.

Disadvantages. The moist gaseous form is destructive and corrosive in its action.

Application. The methods of producing sulphur dioxide are described under "Disinfection and Disinfectants."

Special Uses. Sulphur dioxide is the most useful chemical we possess for rat destruction, especially in ships, warehouses, sewers, and other places, where its use is not barred by its destructive action. The same applies to its use against mosquitoes and other insects.

Hydrocyanic Acid Gas (HCN). This is a light gas with the odor of bitter almonds. It is produced by the action of dilute sulphuric acid on potassium or sodium cyanide.

Advantages. Hydrocyanic acid gas is the most penetrating and most toxic of the insecticides, killing all forms of vermin, mammalian and insect, with certainty and dispatch. The gas has little or no effect on the higher forms of vegetable life, but does possess a limited disinfectant action. Hydrocyanic acid gas does not harm fabrics, pigments, or metals.

Disadvantages. The toxic effect of the gas on higher animal life is its great disadvantage. The slightest carelessness in its use in inhabited buildings or in ships may result in the loss of human life.

Application. Not less than 5 ounces of potassium cyanide or 3.75 ounces of sodium cyanide should be used for each 1000 cubic feet of space to be fumigated. For each ounce of potassium cyanide 1 fluid ounce of commercial sulphuric acid 66 B and 2.5 fluid ounces of water must be used. Each ounce of sodium cyanide requires 1.5 ounces of the acid and 2 ounces of water. First add the water to the acid in a vessel capable of withstanding the heat. As the entire amount of the cyanide must be put into the water at once and the gas is evolved very rapidly, it is well to tie it in a bag of tissue paper or gauze and lower it into the acid by a cord leading outside the compartment or room. If this is not practicable, the operator must be prepared to leave the vicinity instantly.

Special Uses. The gas is most useful in ridding rough or uninhabited structures such as stables, barns, outhouses, warehouses, granaries, and railroad cars of vermin. It is used in sleeping cars against bedbugs, in tobacco warehouses against destructive insects, and in flour-mills against weevils.

Pyrethrum, Buhach, Persian Insect Powder. The flowers of *Chrysanthemum roseum* and *Chrysanthemum carneum.* It kills insects by acting through their breathing pores.

Advantages. It does not corrode metals nor injure pigments or fabrics. The slight deposits or stains sometimes left are easily removed by washing. Pyrethrum powder is used under conditions that make the use of sulphur impossible on account of its injurious action on metals, furniture, tapestries, paintings, etc.

Disadvantages. Pyrethrum is not a reliable insecticide. It stuns, but does not always kill, mosquitoes, also it is quite expensive. Much of the commercial product is impure.

Application. Two pounds of the powder are burned for each 1000 cubic feet of air space, and the exposure should be for not less than four hours. The powder should be burned in pots or pans set on bricks to prevent damage to the floor, and the quantity in each vessel should not exceed 1½ inches in depth. It is ignited after sprinkling with alcohol.

If one source of light is left in the prepared room most of the stunned and dead insects will be found near it, on the window sill or on the floor close to the window. They should be swept up and burned. Sheets of flypaper on the floor near the window will aid in the collection of the dead insects.

Pyrethrum is frequently used as dry powder, in which case it may be used pure or mixed with flour. It should be puffed about the room, especially into cracks.

Special Uses. It is especially useful in those cases where sulphur would cause damage to works of art, tapestries, musical instruments, metal work, and upholstered furniture.

Carbon Bisulphide (CS_2). A clear, colorless liquid, very diffusive. It has a strong, characteristic odor, sometimes fetid from the presence of impurities. It is made by the combination of carbon and sulphur by distillation.

Advantages. It quickly kills all kinds of insect and mammalian vermin.

Disadvantages. Carbon bisulphide is inflammable, explosive, and highly poisonous, therefore it must be kept in well-stoppered bottles in a cool place away from light and fire. When burning, CO_2 and SO_2 are generated.

Application. Carbon bisulphide is rapidly volatilized at ordinary temperatures from open pans. Large, shallow pans are best. Roughly 1 square foot of evaporating surface to every 25 square feet of floor area and ½ to 1 pound of liquid CS_2 are necessary for each square foot of evaporating surface. The pans should be elevated, as the vapor is heavy and settles to the floor. No fire, not even lighted cigars, should be allowed near the exposed liquid and free gas.

When used to kill ground squirrels, balls of waste the size of an orange are saturated with the fluid and placed in the mouths of all the holes of the squirrel warren. The holes are closed with wet clay to prevent the escape of the gas. Carbon bisulphide kills the squirrels and the fleas infesting them, an important consideration when fighting plague.

The waste may be placed deeply in the hole and then ignited. An explosion follows, disseminating the gas to all parts of the warren. This is not so effective as allowing the gas to evaporate slowly.

Petroleum, Kerosene. The application of petroleum as a culicide has been described under "General Prophylaxis." It may be used as the pure oil or as an emulsion, directly or by spraying, against fleas, bedbugs, lice, and roaches. Its use on the floor or other infested places is effective against ants and most other insect vermin. Used on the hairy parts of the body it kills lice.

Formalin. Small quantities of 4 per cent solution of formalin containing sugar placed about rooms attract and kill flies. Otherwise as an insecticide formalin is not to be depended upon.

Camphophenique, Phenol-camphor, Mim's Culicide. Made by liquefying phenol by gentle heat and pouring it over an equal weight of camphor. When moderately heated it gives off rapidly rising but slowly diffusing fumes, which later condense and deposit as a slight moisture. The mosquitoes are stupefied but not always killed.

Advantages. The fumes do not tarnish metals nor injure pigments or fabrics. It is more certain and less expensive and offensive than pyrethrum. A smaller bulk is required, and the fumigation is accomplished in one hour, a saving of time and labor when compared with pyrethrum and sulphur.

Disadvantages. The fumes are irritating to mucous membranes, and may cause carbolic acid poisoning by inhalation. Camphophenique is relatively expensive, uncertain in action, and has slight powers of diffusion. It softens the varnish of surfaces on which it condenses; overheated, it takes fire and is valueless.

Application. Four ounces of camphophenique to every 1000 cubic feet of air space, with an exposure of two hours, are required. The drug should be placed in basins, preferably agate-ware, 8 to 10 ounces to a basin. The basins are heated over alcohol lamps, set in pans of water, not close enough to set fire to the camphophenique, the proper distance to be determined experimentally for each form of lamp.

The following is a brief description of a simple apparatus suggested by Berry and Francis, taken from "Preventive Medicine and Hygiene" by Rosenau: "The basin containing the camphophenique may be set upon a section of galvanized-iron stovepipe, at one end of which sectors are cut out so as to form legs of a length equal to the height of the lamp; just below the upper margin of the pipe a series of holes are punched so as to provide for a draft. The stovepipe should be of such a length as to support the basin containing the camphophenique about 10 inches from the flame.''

Special Uses. Camphophenique is used as a culicide, especially in times of yellow fever epidemics.

Chapter VII

PERSONAL HYGIENE

Many of the aspects of personal hygiene have been discussed in other sections of this work. In this section the endeavor will be made to describe briefly those habits and procedures the practice of which by the individual will tend to promote his general health, and particularly to protect him from the communicable diseases.

Sanitary Habits. These should be engendered in the young at the earliest possible age. As soon as children learn to care for themselves they should be taught to wash their hands after defecation, urination, and before eating. Before they are able to go to the toilet themselves or wash their own hands their parents must see that they are clean before they touch their food. Children have a natural propensity to put their hands and other objects into their mouths. They must be broken of this as early as possible, and taught to keep their hands away from their mouth and nose and to put nothing into the mouth except food and drink. It is needless to say that a large proportion of adults fail to follow these precepts. When we consider that perhaps 90 per cent of all infections are received through the mouth, it is apparent that the observance of these simple rules would be followed by a marked decrease in the communicable diseases.

Care of the Person. *Bathing.* The skin being one of the most important natural defenses against infection, its care is of prime importance. Bathing removes the dirt and infectious matter of external origin and keeps the skin free from waste products of the system, thus permitting it properly to exercise its natural functions. Baths of various kinds are given for therapeutic reasons, and bathing is indulged in for amusement and recreation, but these are not within the province of this work.

More or less arbitrary classifications of local and general baths are made, according as a portion of or the entire body is bathed, and by a division of temperatures as follows: hot, over 98° F.; warm, between 90° and 98° F.; tepid, between 80° and 90° F.; cool, between 65° and 80° F.; and cold, below 65° F.

For cleansing purposes warm and hot baths are the best. They can be borne longer with comfort and they cause a relaxation of the skin which is favorable to complete removal of foreign matter. The skin is reddened and there is profuse perspiration. The pulse and respiration are increased in frequency and the temperature is elevated. The perspiration frequently continues after a warm bath, but may be prevented by sponging the body with cold water at the end of the bath. The sore and aching muscles induced by arduous physical labor are soothed by the warm or hot bath. In addition to removing muscular soreness and pain, the warm bath relaxes and relieves spasmodic conditions or cramps. For those suffering with insomnia, a warm bath just before retiring will often invite a refreshing slumber.

The hot bath (above 98° F.) should not be taken except upon the advice of a physician.

The tepid bath is generally employed for cleansing purposes only, as it has no decided physiological effect. It is preferably taken in the afternoon or just before bedtime, but may be taken any time during the day.

The proper time to bathe is just before a meal or about three hours after. If the blood is diverted from the stomach to the surface of the body by means of a bath the digestion will suffer.

The shower bath is the best way of applying the water to the person, as it immediately removes the foreign matter from all further contact with the skin. One admitting of regulation of the temperature is especially desirable. In default of a shower bath or a tub, a sponge or rag saturated with water, applied repeatedly to the various parts of the body with friction, or merely squeezed out, will serve the purpose. If facilities for complete bathing are not available, one should at least cleanse daily the axillæ, groins, genitals, and feet, in addition to the hands and face.

For thorough cleansing soap is necessary, as water alone cannot dissolve the fatty matters upon the skin. A soap that forms a large amount of lather is not necessarily an efficient cleansing agent, as cocoanut oil is often added for this purpose. Most good soaps are fairly expensive. Soaps alleged to have soothing and medical properties are not to be recommended on that account, as they are of little use except as soap.

The cold bath is essentially a stimulant. Its physiological action is to contract the cutaneous vessels and to drive the blood to the internal organs, causing a pallor of the skin. The respiration is momentarily gasping in character, then slowed and increased in depth. The pulse is somewhat slowed, and the nervous system and mental faculties receive an immediate and powerful stimulus. "Reaction" occurs on emerging from the water; pulse and respiration return to normal, the cutaneous vessels dilate and relax, and the blood returns in increased volume to the surface, giving a sensation of warmth. This is increased if the body gets a good "rub-down."

Cold baths should be taken on rising in the morning, never at night. They should not be taken by those of advanced years, whose arteries are apt to be atheromatous, nor by those with abnormal circulation, as their reaction is not good.

The practice of cold bathing the year around undoubtedly stiffens the defenses of the body against infection, especially catarrhal affections of the respiratory tract.

The pure sea air, the physiological action of cold, the exercise of swimming, and the sense of enjoyment are the factors contributing to the value of sea bathing. The salts contained in the sea water are of no influence whatever. The dirty and expensive mixture sold as sea salt to the gullible public and placed by many in their daily tub baths is absolutely valueless for the purpose for which it is sold.

As a means of cleansing the skin the Turkish bath is without an equal.

A Turkish bath consists of: (1) A dry, hot-air bath at a temperature of from 120° to 170° F., or even higher, for from ten to thirty minutes, which causes in most persons profuse perspiration with no sense of discomfort, but rather a pleasant sensation. After this come: (2) A hot shower bath to wash off the sweat. (3) Shampooing, massage, and scrubbing to remove thoroughly all dirt, loose epithelium, and perspiration from the skin. These take place in moist air at from 100° to 110° F. (4) A warm shower bath gradually changing to a cold one, and then a thorough drying of the body and a rest for a quarter or half hour. A Russian bath differs from this only in that moist air at 150° F. or under is used instead of dry air for the first bath.

It has been said that "a person ought never stay in either the hot-air or steam room if in anywise oppressed, or to use very cold water afterward if one feels any shrinking from it." Nor should one who is very corpulent or who has organic heart disease take a Turkish bath without the advice of a physician. But for healthy persons they are quite pleasant and in most cases beneficial, provided they are not taken too often, and that one does not indulge in them too long at a time. (Egbert.)

Hygiene of the Mouth and Teeth. Much thought and attention are now being given to diseased gums and decayed teeth as possible and probable avenues of infection heretofore looked upon as obscure or "occult." Pyorrhea alveolaris

(Riggs' disease) is no longer believed to depend upon a constitutional condition in some way associated with the so-called uric-acid diathesis. It is now known to be a distinct microbic infection predisposed to by injury to the gums and especially by perforation of the peridental membrane. Such damage is usually caused by the forcible introduction between the gum and tooth of foreign bodies, like seeds of berries, bits of bone, and bristles from the tooth-brush. *X*-ray examinations of the mouth reveal many hidden foci of infection around the teeth, the correction of which is followed by immediate improvement in the general health. Manifestly all of these infections cannot be prevented by the best of care, but their number can be greatly diminished by a proper hygienic regimen of the mouth and teeth.

We assume that bacteria are the cause of dental caries, but much light has yet to be shed upon the subject. Acting upon this assumption, it is our duty to remove as frequently as possible the fragments of food and other matter that find lodgment between and around the teeth and afford opportunity for the growth of bacteria. Catarrhal irritation about the margin of the gums is due in large part to the action of bacteria. This leads to the recession of the gums and exposure of the teeth where they are unprotected by enamel. The continual irritation from tobacco and highly seasoned foods, the presence of tartar, and carelessness in the use of toothbrushes and toothpicks are contributory causes to this unhealthful catarrhal condition.

In the light of our present knowledge it may be stated that the preservation of the teeth and the keeping of the mouth in a healthy condition depend upon the following simple principles: The avoidance of chemical and mechanical injury to the teeth and gums, the prevention of overcrowding of the teeth, frequent and careful cleansing of the exposed surfaces of the teeth, and the use of antiseptic mouth washes. To this end the frequent use of the tooth-brush is indispensable. The bristles of the brush should be wide enough apart to admit of their passage between the teeth. The brush should be discarded before it is ragged and soft. It should not be too broad, and the handle should be bent in the direction of the side into which the bristles are inserted so as to permit of more easily reaching of the various curved surfaces of the teeth. The teeth should be brushed after every meal and before retiring. This, however, is seldom practicable. Probably the most convenient times for most people is on rising in the morning and at bedtime. At least once daily a good tooth powder should be used. Powdered chalk and orris root are the bases for most of the commercial powders. If the powder is too soft or too fine it is almost useless. One of the mild antiseptics such as tincture of myrrh, one of the essential oils or borax is ordinarily incorporated in the powder. Tooth powders are better than the dental creams, which are composed largely of sugar and soap. After brushing the teeth the mouth should be washed with a mouth wash such as listerine, about one part to three of water.

A good practice is to go frequently over the exposed surfaces of the teeth with a small chisel-like piece of orange wood and some tooth powder. This gives the teeth a good polish and renders their cleansing easier than with the tooth-brush.

A valuable prophylactic measure is the daily use of soft, silk thread, sold under the name of dental floss, which, when drawn firmly between the teeth, removes foreign matter that cannot otherwise be reached. This should be carefully done so as not to cut or irritate the gums nor to loosen their attachments to the teeth.

Rest and Recreation. No person can remain healthy in mind and body without a daily period of rest and recreation. Monotony of life predisposes to mental troubles, and mental worry has caused more mental deterioration than mental activity. Each person is a law unto himself as to the amount of work that may be performed without danger of mental, nervous, and physical breakdown. It is quite impossible to apply any given rule governing the amount of sleep to all persons indifferently, as active minds may require much less than is ordinarily considered necessary, and persons of small mental caliber may require much more. This fact is impressed upon us when we consider that Edison, the great inventor, performs his herculean labors on two to three hours' sleep in the twenty-four, and that the average cornfield negro can sleep the clock around without an effort. It is generally assumed that the average man needs, for the repair of bodily waste, about eight hours sleep a day, but the amount of sleep required is a matter of habit, age, and temperament. As a rule the young require more sleep than those of advanced years. It is a generally accepted fact that the sleep taken in the early hours of the night is the most refreshing. Many persons, especially sea-faring men, acquire the habit of sleeping at any time in the twenty-four hours, apparently without detriment to their health.

The following excellent rules are from Rohé's "Text-Book of Hygiene," and should be observed whenever possible.

Do not eat heavy meals at night. Have fresh air in the sleeping room the year around, but do not have the bed in a draught. Do not sleep with an artificial light burning in the room; it requires increased provision for ventilation, and, by shining in the eyes, promotes inflammatory troubles of the lids. Do not have carpets or hangings in the sleeping room, but let the furniture be of the very simplest kind. If two people occupy the same room, they should occupy separate beds. Do not sleep in any garments worn during the day. Have the night-garments loose and comfortable; warm in winter, cool in summer. Have the bed-coverings light but warm, remembering that a number of layers makes a warmer covering than the same weight of material woven in one piece. Do not sleep on feather beds. Sleep with the head low and not with it propped up on several pillows, because this interferes with deep breathing, contracts the chest, and favors stoop shoulders. Lie on the right side when you first go to bed; it hastens food which may be in the stomach toward the pylorus and aids digestion, favoring natural sleep.

There is a hygienic measure of great value, the use of which has become more and more common during the past two decades—the practice of outdoor sleeping. The best ventilated sleeping room is far inferior in healthfulness to an outdoor sleeping porch, open window, or window tent (large enough to include the whole bed). Many houses, especially in California and the South, but also in the Northern States, are now built with sleeping porches as part of every bedroom. Outdoor sleeping was first introduced for the treatment of pulmonary tuberculosis, later for other respiratory troubles and for nervous diseases. Latterly its value has become widely recognized for *well* persons of all classes and all ages. Outdoor sleeping increases the power to resist disease, and greatly promotes physical vigor, endurance, and working power.

The laity were slow to understand that the night air, especially in cities, is much purer than day air, on account of the fact that there is much less traffic at night to stir up the dust. They dreaded the "miasms" of malaria that the night air might bring. To-day the sleeping porch, screened to keep out the anopheles mosquitoes and other insects, is a common sight.

Sleeping porches or balconies should be protected from the wind by a sash on one or two—or in very windy places—three sides. There should not be too much protection, as the measure loses in efficiency if free currents of air are not secured.

A roll curtain (preferably rolling from the bottom) should be provided on the open side or sides, to be used only in case of storms. In cold weather a thick mattress, or two mattresses, should be used. The body should be warmly clad, and the head and neck protected by a warm cap or helmet or hood. To prevent the entrance of cold air under the bedclothes, one or more blankets should be extended at least two feet beyond the head, with a central slit for the head. Early awakening by the light may, if necessary, be prevented by touching the eyelids with burnt cork, or by bandaging the eyes with a black cloth or stocking. Sheets should be well warmed in the wintertime before being used. They can easily be warmed with a hot-water bag, flatiron, or soapstone. Blankets next to the skin are not hygienic. Where a sleeping porch is not available, an inward window tent can always be had which puts the sleeper practically out of doors and at the same time cuts off his tent from the rest of the room. If an outdoor tent is used it must be kept well opened; otherwise it fails of its purpose, as the tightly woven canvas is impervious to air. (Fisher and Fisk.)

Recreation does not mean idleness. It means rather a change of occupation, the practice of an avocation, possibly hard physical work. By recreation the mind and body are relaxed from the day's routine and cares and exercised along other lines. Many persons are benefited by working at an avocation or hobby out of regular working hours. Writing stories, painting pictures, and photography come under this head. Many persons find their recreations in walks or strolls, others in games of various sorts, still others in the theaters and moving-picture shows. The tired business man and the energetic school child alike find recreation at the "movies." The proper kind of reading is often a most beneficial form of recreation. It is well, however, for the average individual to avoid literature that deals with the morbid and pathological, that depicts and analyzes psychological conditions.

Dancing combines a most wholesome exercise, social enjoyment, and the acquirement of skill and grace. It is to be highly recommended unless its indulgence involves bad air and loss of sleep, due to dances being held in poorly ventilated places and lasting until the late hours.

Card-playing and similar games are enjoyed by some. Their hygienic value is exceedingly doubtful, as they are liable to be associated with late hours, poorly ventilated rooms, etc., and card-playing in particular is apt to degenerate into gambling and be associated with other forms of dissipation.

Physical Exercise. Exercise has a wider meaning than the mere action of the voluntary muscles. Not only must work be performed, e.g., resistance overcome, but every organ and tissue in the body must be exercised in some way or other. The functions of the body can be maintained in a healthy state only by more or less constant use. Also, the systematic use of an organ makes it more effective in the performance of its functions. Deficiency in exercise causes a lack of nutrition, wasting in size, and eventually degeneration of the tissues, while too much exercise favors hypertrophy and later tissue degeneration.

Exercise, to be of value, must not only be regular, but the contraction of the muscles must be of sufficient force to assure the constant disintegration and renewal of the tissues, for upon this renovation depend the strength and vigor of all parts of the body.

Proper physical exercise makes the voluntary muscles larger, harder, stronger, and more quickly responsive to the will, and increases the functional capacity of the involuntary muscles involved. Health and strength are promoted and consequently ability to resist disease increased by quickening the circulation and increasing the respiratory powers. During muscular contraction potential energy is converted into kinetic energy, more food and oxygen are called for and consumed, and more carbon dioxide and other waste matters are produced and eliminated.

One of the greatest advantages of physical exercise is the increased action of the respiratory organs, the lungs being expanded and the respiration increased in frequency and depth. Many cases of pulmonary tuberculosis would be prevented by the more general practice of suitable exercises and proper breathing. During exercise all tightness of clothing, especially about the waist, neck, and chest, should be avoided, in order that there shall be nothing to impede the circulation or the action of the chest and lungs. As the amount of carbon dioxide and other waste matters eliminated is very much increased during exercise, a much larger amount of pure air is needed, therefore the rooms and buildings in which exercises are held should be thoroughly ventilated.

Exercise increases the force and frequency of the heart beat; the pulse becomes full and strong if the work is not too excessive or sudden. Unless the heart is overtaxed the pulse-beats are regular and even, but suddenly increased exertion may cause the rate to become very rapid—the normal increase during exercise is from ten to thirty beats per minute. Excessive exercise leads to cardiac palpitation and hypertrophy, while deficient exercise favors weakening of the heart muscle, and not infrequently leads to dilatation and fatty degeneration.

Exercise increases the amount of perspiration, and the evaporation of the fluid tends to keep the body cool. On account of the great heat production there is not much danger of chilling the body during exercise, but as soon as work is stopped heat production is checked and the body rapidly cools, especially in a draught or breeze, and there is danger of chilling unless more clothing is donned. Sweaters or flannels, being made of wool, which is a non-conductor of heat and hygroscopic, are the best for this purpose, as they prevent a too rapid cooling of the body. The skin must be kept clean so that there is no interference with the functions of the sweat glands.

The appetite is increased by exercise, due to the increased circulation of the blood through the vessels of the alimentary tract and the liver and to the increased demand of the muscles for food.

"If exercise be taken too soon before meals, either the stomach, by calling the blood from the exhausted muscles, will prevent their proper repair and rest; or the muscles, calling the blood from the stomach, will prevent the proper formation of the gastric juice when food is introduced. If exercise be taken too soon after eating, it is apt to prevent the flow of blood to the organs of digestion and the formation of the digestive juices; or, by forcing the contents of the stomach into the intestines before gastric digestion is completed and before the food has reached a condition in which the intestines can make use of it, to cause intestinal irritation and indigestion." (Egbert.)

Properly balanced physical exercise favors a symmetrical mental development, as it not only causes more blood containing food and oxygen to circulate in the brain, but exercise of the functions of the cerebral centers, especially those of coordination, tends to the growth and development of these centers.

The purpose of physical training is to strengthen the heart and circulation, to increase the lung capacity and the respiratory power, to invigorate the central nervous system, to improve digestion and consequently nutrition, to strengthen the voluntary muscles, increase their capacity for endurance, and bring them more perfectly under the control of the will, and to decrease the amount of adipose tissue. The systematic exercise involved in physical training aids materially in the elimination of waste matters; the pores, glands, and organs are kept at work and healthy, and, by constant renovation, weak and sluggish tissues are replaced by fresh and active ones.

Fatigue is due to exhaustion of nerve-force and motor impulses from the brain, to lack of contractile material in the muscle fibers, and to the accumulation in the muscles of waste products.

Active exercise is the result of one's own volition. Passive exercise is produced by force outside the body.

The best authorities agree that the average healthy man should do work approximating the equivalent of 150 foot-tons daily. It is estimated that a man of 150 pounds walking one mile on a level at 3 miles an hour does work equal to 17.67 foot-tons, therefore his total daily physical labor should be equivalent to walking about 9 miles at the above rate to get the proper amount of daily exercise. This is apparently an excessive amount, but if the actual physical work done in the performance of one's daily routine of duties and labors be deducted from this, the remaining margin to be devoted to physical exercise as such is not great.

Kinds of Physical Exercise. The Americans and English prefer athletic sports and outdoor games: the peoples of Continental Europe, especially the Swedes and Germans, are much given to systematic indoor gymnastic exercises directed to the development, in due order and proportion, of all the muscles of the body. Both attain splendid results, but the best systems of physical training, especially for children and young people during the period of growth, embody open-air sports and regular gymnastic exercises. Outdoor sports and games are, in general, carried on under more healthful conditions and, as a rule, afford a greater amount of exhilaration and recreation than formal exercises conducted in a gymnasium or bedroom. More enthusiasm attends the playing of outdoor games than the practice of monotonous gymnastic routines, therefore they are not so liable to be shirked on slight pretexts. The development of muscles and education of movements produced by them is, however, apt to be somewhat lopsided and haphazard, therefore the two systems should supplement each other.

Some persons can and do take a certain amount daily of indoor exercise either in their own rooms or in the gymnasium, generally with the aid of appliances such as Indian clubs, dumb-bells, chest-weights, rowing machines, etc., and enjoy it and profit by it. The enthusiasm of the average person for such wearisome work generally wears off a few days after the purchase of the appliances.

Golf is a capital form of exercise for all ages above early childhood, but especially for those who lead sedentary lives or whose age bars them from the more active games. The amount of work that is performed in going the rounds of a golf course is not appreciated at the time, on account of the ever-changing scene, the pleasant surroundings, and frequently the congenial company.

Tennis, baseball, football, and other outdoor sports bring the whole body into action and are valuable if not carried to excess. The rapidity of the play cannot be varied according to the fatigue of the individual, as is the case with bicycling and golf.

Rowing is a healthful exercise, but the violent exertion required in the sustained effort of racing is sometimes the cause of functional and organic heart troubles.

Swimming, properly regulated according to the age of the swimmer, temperature of the water, duration of the exercise, etc., is one of the very best of athletic exercises. Every muscle in the body is brought into play, and it is a sport that seldom palls on its devotees. It possesses the additional merit of not infrequently being the means of saving the life not only of the swimmer himself, but of other persons.

Boxing and wrestling are preëminently the sports of vigorous boyhood and manhood. Self-confidence is engendered, the muscles are strengthened and coördinated, and the nervous system invigorated.

Regulation of the Diet. It is inadvisable to attempt here a dissertation on the physiology of digestion, dietetics, etc.; a working knowledge of these subjects on the part of the reader is presumed by the writer.

"Each individual must decide for himself what is the right amount of food to eat. In general, that amount is right which will maintain the most favorable condition of weight. If the weight, endurance, and general feeling of well-being are maintained, one may assume that sufficient food is taken.'' (Fisher and Fisk.)

Food values are expressed in terms of fuel-units, called calories. A man of average weight leading a sedentary life requires about 2500 calories a day. The larger the person, assuming that the bulk is due to muscle and not to fat, or the more muscular work he does, the more food he requires. Weight, especially in relation to age, is an important factor in influencing longevity. Except in the earlier ages of life, overweight (reckoned relatively to the average for that age) is a more unfavorable condition, in its influence on longevity, than underweight. (Fisher and Fisk.) Fifteen or twenty pounds overweight after the age of thirty-five is a matter for serious thought. Habits of diet and exercise should be formed that will keep the weight down automatically. Intermittent attempts at ''reducing'' as a rule are only temporarily successful and frequently fail.

Many people overeat without realizing it. Many articles of food, such as candy, fruits, nuts—especially peanuts—ice cream, and popcorn are often eaten between meals and overlooked in computing the daily consumption of food. The same applies to butter and cream eaten with the meals. These foods have high food value, and frequently raise the total number of calories much above the normal requirements. In partaking of meals one who is careful of his diet will bear in mind the food eaten between meals and be governed accordingly.

In middle life and in old age less of the animal foods should be consumed, and fruits and vegetables, especially those leaving a large residue in the intestines and having a low food value, should form the most important part of the diet. These include lettuce, turnips, carrots, parsnips, tomatoes, celery, salsify, and oyster-plant.

As a rule it is advisable to eat somewhat less in hot weather, as fewer calories are needed to sustain the heat of the body. This applies particularly to meat, as protein and fat are the principal heat-producing constituents of food.

It is muscular effort and not mental work that consumes the greater part of the ingested food. If the sedentary brain-worker gains weight while eating comparatively little food he should take regular and systematic exercise. If he cannot or will not take exercise, then he should materially reduce the amount of food he eats.

In these days of war, pestilence, and famine and the constantly rising cost of living it is absolutely futile for a writer on personal hygiene to attempt to formulate any system of rules, applicable to all classes, for the selection of diet and the regulation of hours of eating with reference to the daily duties of life. Suggestions as to light breakfasts, more substantial luncheons, and hearty dinners in the evening, with periods of mental and physical rest after each meal are now largely of academic interest. Times and men and manners and conditions have changed since such didactic precepts could be followed by any considerable portion of the population. If possible, heavy meals just before heavy work should be avoided, but this must necessarily depend upon one's daily program of work and duties. When fatigued it is sometimes advisable to skip a meal or to eat only lightly, as of fruits and salads. Eating when very tired favors indigestion.

A common dietetic error of Americans has been the consumption of too much protein. Some authorities claim that from two to three times too much is consumed by many Americans. This is usually due to the extensive use of meat and eggs, though the same error may be committed by the excessive use of other foods containing a high percentage of protein, such as fish, shell-fish, fowl, cheese, peas, and beans, and in exceptional cases by the use of foods less high in protein when combined with the absence of any foods very low in protein. Hygienists have protested against this exaggerated meat diet for some years with but slight results. The great scarcity of food now prevailing throughout the world, while causing actual suffering and deprivation to many millions of people, will prove an indirect benefit to many others by enforcing a curtailment of their meat allowance, with a consequent improvement in their health.

Many people are prone to avoid hard foods that resist the pressure of the teeth, like toast, crusts, crackers, hard fruits, fibrous vegetables, and nuts. These foods, as they exercise and preserve the teeth and insure the flow of saliva and gastric juice, are an important feature of a hygienic diet. Many of the ordinary foods are too concentrated; they lack bulk and leave too little residue in the intestines, and consequently favor constipation. In view of this there should be daily consumed a fair amount of food containing cellulose. The foods containing the largest proportion of this substance are the fibrous fruits and vegetables—berries, corn, spinach, cabbage, lettuce, celery, asparagus, cauliflower, onions, tomatoes, parsnips, squash, pumpkins, etc.

Important though small components of foods are the vitamins. They are destroyed by the prolonged cooking at high temperature necessary to sterilize canned foods; they are also diminished by ordinary cooking. They are found in most foods but particularly in the skin or coating of grains, especially rice, in yolk of egg, raw milk, fresh fruit, and fresh vegetables, especially peas and beans. These vitamins are important for the life and the well-being of the body. Their absence apparently causes emaciation, lack of growth, and such diseases as beriberi, scurvy, and probably pellagra. In order to supply these substances, raw or uncooked foods such as fruits, lettuce, celery, tomatoes, nuts, and milk should form part of the regular diet.

Most Americans eat too rapidly. Thorough mastication does not mean counting the chews and forcibly holding the food in the mouth. It means masticating to the point of involuntary swallowing and giving up the habit of forcing the food down, and applies alike to solids and liquids. The latter should be sipped.

"The consequences and evils of insufficient mastication are many, and may be enumerated as follows: Insufficient use of the teeth and jaws (and hence dental decay as well as other and worse dental evils); insufficient saliva mixed with the food (and hence imperfect digestion of the starchy substances); insufficient sub-division of food by mastication (and hence slow digestion); the failure of the taste nerves to telegraph ahead, as it were, to the stomach and other digestive organs an intimation of the kind and amount of digestive juices required (and hence indigestion); the overseasoning of food to make it relishable even when bolted (and hence overeating and irritation of the mucous lining); the excessive use of meat and eggs and like foods, which can be eaten rapidly with relative impunity, and the corresponding neglect of other foods, like bread, grains, vegetables, and salads, which require more mastication (and hence intestinal poisoning)." (Fisher and Fisk.)

The first efforts to correct the evil habit of eating too rapidly require some conscious attention. If the first three mouthfuls of a meal are slowly chewed the slow rate can frequently be maintained without further thought for the rest of the meal. Slow eating furthermore adds to the taste and enjoyment of a meal. To be most readily assimilated food must have a pleasing taste and flavor and then the eating of it must be enjoyed.

Clothing. The main objects sought in clothing are: (1) To protect the body from cold, heat, injurious light rays, wind, rain, and other moisture; (2) to maintain the temperature and, by preventing the loss of animal heat, to diminish to some extent the demands for food; (3) to permit the evaporation of moisture from the skin to proceed with as little hindrance as possible; (4) to avoid the compression of the body in so far as may be possible; (5) to allow all muscular acts the greatest possible freedom; (6) to protect the body from injury; (7) to comply with the demands of modern civilized communities that the nude body shall not be exposed in public, but at the same time to disguise as little as may be the natural beauties of the human figure; (8) to adorn the body.

The materials from which articles of clothing are usually manufactured are wool, silk, furs, leather, cotton, linen, and rubber. It is impossible to describe these in detail in a manual of this size. In discussing the value of different substances as materials for clothing the two most important physical properties to be considered are their power of conducting heat and capacity for absorbing moisture.

The heat-conducting power of a fabric depends more on the manner in which it is woven than on the structure and composition of the individual fibers. Dry air is a poor conductor of heat, and any fabric which is loosely woven in such a way as to entangle large quantities of air in its meshes will prevent either sudden lowering or raising of the body temperature and will consequently make a warm garment. Wool is generally woven in this manner, is probably the most valuable of clothing materials, and is the safest for use in climates having sudden changes of temperature. Wool is also very hygroscopic, readily taking up moisture and giving it off slowly, thus reducing cooling by evaporation to a minimum and regulating the heat-dissipation of the body. Persons who are subject to rheumatism or are susceptible to sudden changes of temperature should always wear woolen underclothing, varying the thickness and weight to suit the season. Undergarments are now made of pure wool and of mixtures of wool and cotton that are not irritating to the most sensitive skin. Some of these methods provide for the escape of moisture from the material and for the free permeation of air through the interstices of the fabric.

Silk is a poor heat conductor and is almost as hygroscopic as wool. It has a great affinity for dyes and is an excellent material from which to make warm clothing, especially undergarments, but is very costly.

Cotton is hard, durable, and cheap; its hygroscopic power is low and its heat conductivity high; it does not shrink in washing, and makes extremely cool clothing for warm seasons and climates. Warm clothes are made from cotton woven so as to have large air-spaces in the fabric, resembling the loose texture of woolen fabrics. Cotton is employed with wool and other materials as an adulterant, or to combine the useful properties of each, as, for example, in merino, largely used in the manufacture of stockings and underclothes. Cotton garments should not be worn next the skin by those subject to sudden changes of temperature, nor during exercise, unless in the latter case it is changed immediately after the exercise, or additional clothing, preferably woolen, is put on to prevent too rapid evaporation and cooling.

Linen goods are heavier than cotton, lustrous, smooth, and very durable. The color of linen is very pure when bleached; its hygroscopic and heat-conducting properties are about the same as those of cotton. It is especially useful for outer garments in hot climates.

Leather is durable, pliable, hygroscopic, but sufficiently waterproof for ordinary use, especially when oiled. It is in general use for foot-coverings of various types. On account of its resistance to the wind and the efficacy with which it keeps the body surrounded with a layer of warm air it is used for body garments in cold climates, by aviators and by sailors cruising in cold latitudes.

Fur is invaluable as a protection against wind and cold. It is impermeable to the wind, and has very low heat conductivity, due principally to the large amount of air retained between the hairs.

Rubber is durable, flexible, and impermeable to air and moisture. It is employed in the manufacture of overshoes and other foot coverings, and in the form of waterproof cloth known as mackintosh is used for rainproof garments of various kinds. Rubber garments are hot and confine the watery vapor given off by the skin. They should, therefore, be ventilated as much as practicable, especially when worn in high or moderate temperatures. Clothing is now made waterproof and at the same time permeable to the air by a number of processes. Such material is to be preferred to the impermeable fabrics.

Clothing should not be needlessly heavy, should not in any way impede the natural movements, should not unduly constrict any part of the body, nor should it afford any unnatural support. These defects are emphasized particularly by long and close-fitting skirts, corsets, garters, bands around the waist and neck, tight sleeves, ill-fitting gloves, hats, and shoes. Attention to the following points would tend to obviate the faults of modern dress: (1) No article of clothing should be either so tight as to interfere with circulation, or so shaped as to change the natural outline of any part of the body; (2) no garment should contain more material than is actually necessary; (3) all garments requiring suspension should be suspended directly or indirectly from the shoulders or hips. (Notter.)

The practice of most women of compressing the body unnaturally by means of various kinds of stays continues in spite of the protests of practically all physicians and teachers of physical culture. Corsets interfere with the fullest attainment of health and vigor. They prevent proper muscular development, as no vigorous exercise can be taken by a tightly laced woman. The constriction of the waist causes a change in position and interferes with the functions of many of the internal organs, especially those of the abdomen and pelvis.

The tight corset lessens the amount of air that can be taken into the lungs, consequently the blood is imperfectly aerated, and this leads to anemia. The feeling of "utter collapse" that some women complain of when the corset is laid aside is due to the imperfect development of muscles that are not employed when corsets are worn, but which should be strengthened by systematic exercise to enable them to properly support the abdominal and pelvic viscera.

The wearing of articles of apparel that constrict the parts they cover is not confined to women. Men frequently wear belts, neckwear, garters, etc., that are too tight, and the stiff hats generally worn by men check the circulation in the scalp and are a cause of premature baldness. Tight, circular garters predispose to varicose veins. The more hygienic plan is to suspend the stockings from some part of the underclothing.

Personal comfort depends greatly upon perfectly fitting shoes. Vanity and the demands of fashion cause many people, especially women, to attempt to fit the foot to the shoe instead of the shoe to the foot. The result is the agonizing period known as "breaking in" shoes. A sensible form of shoe is not too narrow and pointed, nor on the other hand is it necessary to have it perfectly square, as is seen in some of the so-called common-sense shoes. In a well-made pair of shoes the inner sides should be nearly parallel and not diverge greatly when the wearer stands with feet together. Several anatomical types of shoes are now on the market and are worn with comfort by both sexes. It is essential to comfort that a shoe be sufficiently long. A good general rule is to have the shoe at least three-quarters of an inch longer than the foot. Adherence to these rules may prevent corns, bunions, callosities, and other more serious foot troubles.

The heels of shoes should always be broad and low. The high heels so frequently worn by women for the purpose of increasing their height and lessening the apparent size of the foot tend to produce weakness of the arch through atrophy of the plantar ligaments. Low shoes allow excellent ventilation of the foot and are to be preferred to high ones in warm seasons and climates.

Students of hygiene now agree that the question of clothing is closely related to the question of ventilation, and that air hygiene concerns the skin as well as the lungs. Therefore the hygiene of clothing assumes a new and hitherto unsuspected importance. Loose, porous underclothes are gaining in favor, but effective ventilation, such as will allow free access of air to the skin, requires that outer clothing, including women's gowns and men's shirts, vests, vest-linings, and coat-linings, should also be loose and porous. Most linings and many fabrics used in outer clothes are so tightly woven as to be impervious to air. Porous fabrics, including porous alpacas for lining, are always available.

"At times we can enjoy relief from clothing altogether. An air bath promotes a healthy skin and aids it in the performance of its normal functions. Any one can spend at least a little time in a state of nature. Both at the time of rising in the morning and upon retiring at night, there are many things which are usually done while one's clothes are on which could be done just as well while they are off. Brushing the teeth, washing the hands, shaving, etc., necessarily consume some time, during which the luxury of an air bath can be enjoyed. Exercises should also be taken at these times. Exercising in cold air, *if not too cold,* with clothing removed, is an excellent means of hardening the skin and promoting good digestion." (Fisher and Fisk.)

Those who clothe themselves properly become more independent of changing weather conditions. They do not suffer greatly from extreme cold and heat and "raw" days no longer make them uncomfortable.

Chapter VIII

HOSPITALS

The limitations of this work are such that a general description of hospitals would be out of place, therefore the discussion of the subject will be confined to a brief exposition of the principles governing the construction of hospitals for communicable diseases and the hospital care of those diseases.

A properly equipped and well-conducted hospital for communicable diseases is a sanitary and economic asset to any community. Undoubtedly hospital treatment saves many lives, particularly among patients suffering from diphtheria, cerebrospinal meningitis, and other diseases, when special skilled treatment and apparatus are needed which are not available or cannot be afforded in the home. The exact value of hospitals in combatting or ''stamping out'' communicable diseases is hard to estimate; probably their influence has been greater in decreasing the mortality rather than the incidence of these infections. A good hospital for communicable diseases solves many difficult problems for the physician when called to this class of cases. It decreases the danger to members of the family, and it prevents interruption of the work of the breadwinner and the school attendance of the children. It is logical and humane that such diseases as diphtheria, scarlet fever, cerebrospinal meningitis, smallpox, erysipelas, measles, whooping cough, and chicken pox should receive the best of hospital care and treatment. The time is passed when a person suffering with one of the communicable diseases was treated as a pariah and it was necessary either to care for him in his home, where he was a menace to others, or remove him to a foul pest-house. Improved methods of nursing and hospital construction have remedied this evil.

The aseptic technic method or medical asepsis is the method now in use by enlightened physicians and sanitarians for the care of the communicable diseases. This method ignores the air borne theory of the spread of the communicable diseases, within three feet of the bed, and supports the idea that the great majority of these diseases are communicated from one individual to another, or from one place to another, by means of direct or indirect contact. In other words, the infected person has come either in direct contact with the patient or with something that has, directly or indirectly, touched him. It is applicable to specially constructed communicable disease hospitals, and to the communicable disease wards of general hospitals, which either receive cases from the outside or care only for those which may develop in the hospital. A strict observance of its precepts enables competent and well trained nurses to care for communicable cases in the home and, in extreme emergencies, in the medical wards of a general hospital, with a minimum of danger to other members of the family or to other patients in the ward. Absolute isolation of patient and nurse is no longer necessary. The method permits of ward nursing whereby the time of a nurse, which cannot be fully occupied with the needs of a single patient, may be utilized to care for several others.

It has been urged against medical asepsis that it requires a highly trained set of nurses and other attendants to practice the method successfully. The same, however, may be said of a surgical operating room. Nurses and physicians must be as well trained in the principles of medical asepsis as they are in those of surgical asepsis.

The barrier or cubicle system implies the confinement of communicable disease patients in wards, rooms, cubicles or within spaces delimited by screens or even tapes or cords without absolute isolation. Under these circumstances the prevention of cross-infections is left entirely to the technical methods of medical asepsis. We now have ample proof that this is a practical and efficient system, nevertheless an additional margin of safety is attained by architectural isolation and communicable disease hospitals should be constructed accordingly. The cubicles may be embodied as integral parts of the building or the hospital may be divided into units, thereby securing absolute architectural isolation. The latter is of prime importance in small communities and in communicable disease hospitals which are auxiliaries of general hospitals in cities having public hospitals for communicable diseases, where cases are not constantly under treatment, and where a single emergency case is likely to arise and untrained help must be employed at very short notice. Under these conditions the principles governing the planning of the hospital should be based on the assumption that the technic of treating patients afflicted with communicable diseases should follow the line of least resistance, i. e., that physical segregation by means of walls and other structural barriers and the use of articles which obviously indicate their intended function, will compel the attendants to the performance of certain duties and make the probability of failure to comply with the rules of medical asepsis and isolation less likely to occur and also prevent carelessness. The fact of the hospital being so constructed as to permit the absolute isolation of patients and nurses does not lessen the importance of bedside disinfection.

Hospital Sites.—Attractive locations for public buildings or even for residences are rarely suitable for hospitals. In view of the fact that the sojourn of patients in hospitals for the acute communicable diseases is relatively short, the location of these hospitals is not so important as that for general or for other special types of hospitals. As communicable disease hospitals are no longer looked upon as "pest houses," that contaminate the surrounding atmosphere, it is not necessary to place them in isolated localities. However, the following points should be borne in mind when choosing a location: the contour of the land, the surrounding country, the aspect, the accessibility for friends of the patients and for visiting physicians, remoteness from disturbing influences, and a site of sufficient size to insure privacy.

A southern exposure is always desirable, with the land sloping toward the south. If in the country, it is still more advantageous if the north is protected by evergreen trees. Enough land should be provided for possible growth of the institution. If the cite is in the city, the same care in selection should be exercised. Smoke from adjoining chimneys, noise from nearby railroads, and proximity to a noisy thoroughfare or factory are menaces to be considered.

Types of Hospital Buildings. The plans of hospitals or wards for communicable diseases differ according to the system adopted for the control of the diseases. Many of our newer American hospitals are being built on the cubicle plan, in which a careful observance of aseptic technic is depended upon to prevent cross-infections. Others, especially those in small communities and the communicable disease wards or pavilions of general hospitals that do not receive cases from the outside, are built with the view of preventing cross-infections largely by architectural isolation.

Hospitals embodying the cubicle system should be planned:

1st—So that the nurse or doctor, after contact with the patient, can have ample and immediate opportunity to scrub the hands.

2nd—So that sterilizers can be provided for sterilizing every article that goes to the patient or is taken from the patient.

3rd—So that provision can be made for the removal and destruction of waste, either by local incinerators or properly protected receptacles to convey to the general destroyer. (Stevens.)

In a hospital or ward so equipped and administered by a *well trained and intelligent personnel* cases of scarlet fever, diphtheria, erysipelas, measles, cerebrospinal meningitis and other communicable diseases may be cared for in adjoining cubicles or rooms by the same physicians and nurses, and the

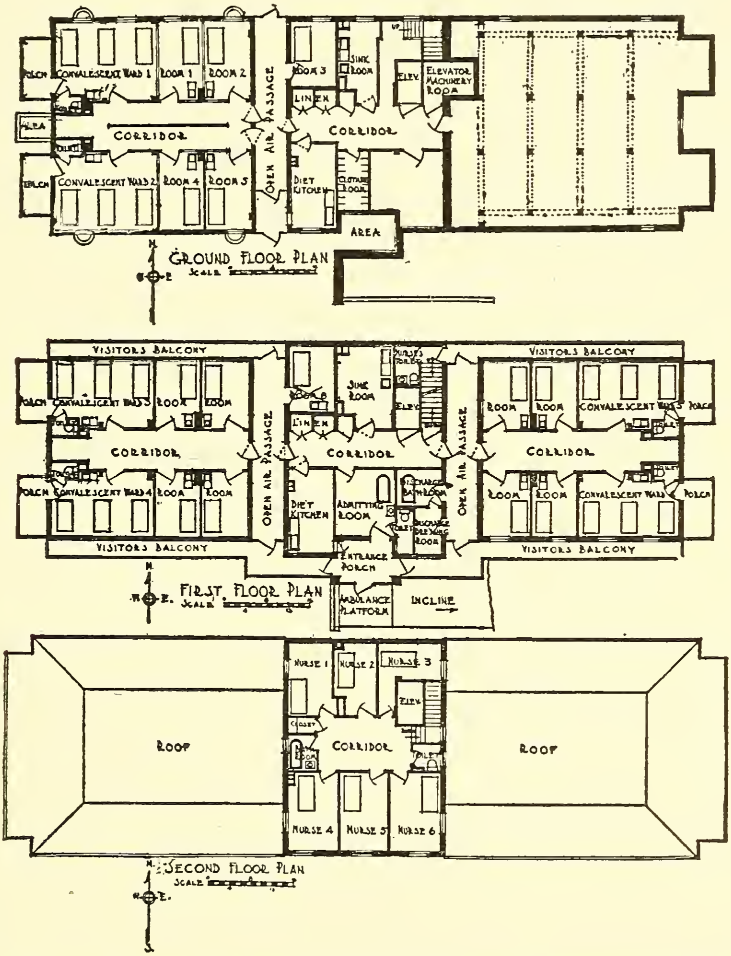


FIG. 24.—FLOOR PLANS OF THE WHITE ISOLATION BUILDING, ST. LUKE'S HOSPITAL, JACKSONVILLE, FLA. (*Stevens.*)

latter may eat in the same dining-room and live in the same nurses' home with nurses of other departments of a general hospital. Smallpox is still cared for at a distance from other people, largely on account of popular prejudice. As the service becomes larger or the diagnosis of the cases surer, the grouping of the various diseases in different buildings becomes an economy, but the technic is never relaxed.

The following is an abstract of the description of the communicable disease department of St. Luke's Hospital, Jacksonville, Florida, given by Mr. Edward F. Stevens in his book, "The American Hospital of the Twentieth Century."

The plan is an adaptation of the Pasteur Hospital of Paris and does away with all the cumbersome and elaborate arrangements of the old school. There are single rooms for fresh cases and wards for convalescents. The rooms are cubicles, with glass partitions for ease of observation, each cubicle being a separate entity, complete in itself, with all the facilities for carrying out the correct technic of aseptic nursing.

The central portion of the building is the administrative department, being occupied by the admitting and discharge rooms and the various utilities, with the office of the nurse in charge. An open air cut-off separates this from the part occupied by patients.

Each room or ward is furnished with a scrub-up sink, with elbow faucets, so that after any service for the patient the physician and the nurse can scrub and disinfect their hands before leaving the room. They also wear gowns while caring for the patient, leaving them on hooks *inside* the door before they depart.

The equipment consists of utensil sterilizers, which can be opened by the foot; elbow handles for the faucets over slop sinks; dish sterilizers large enough to take a tray and its dishes; garbage incinerators which may be opened by elbow; liquid soap dispensers with pedal action; lever door handles which can be opened by elbow or upper arm; and everywhere scrub-up sinks with elbow handles. By means of these carefully worked out details the nurse is enabled to care for the patient, dispose of all waste material, and accomplish the disinfection of all utensils and appliances used in the process, without touching anything else. At the close of each procedure she sterilizes her hands and removes her infected gown, becoming clean again, to start on another round with another patient.

When a patient is admitted, he is bathed on the shallow tub-slab with a spray, so he gets what is practically a shower-bath or shampoo in running water. He is then placed in a single room. When convalescent, he is transferred to the small ward where there may be other patients recovering from the same disease. This ward is treated as a unit, but the aseptic technic is still carried out.

A portable tub, similar in principle to the one in the admitting room but made of wood covered with copper for lightness, set on a wheeled stretcher frame of the same height as the beds, is also provided. This may be taken to any room, the patient transferred to it, and bathed with a spray attached to the faucet at the scrub-up sink. A floor drain in each room receives the waste water from the tub. The tub is disinfected after each using.

When a patient has recovered and is to be discharged, he is taken through the open air corridor to the discharge room, given a cleansing and disinfecting bath, and passed into the dressing room, where he receives his own uninfected clothing. From this room he departs without coming into contact with other persons or parts of the buildings.

Hospital finish of the simplest and strictest sort has been carried out in this pavilion and everything made so as to be easily cleaned. The furniture is extremely simple, the rooms having no more than a bed, a comfortable chair, and a table, besides the all-important sink or lavatory. These sinks are made special, being provided with an integral drain-board upon which to place hand brushes and other appliances.

The convalescent wards have toilets directly off them, and each has its own screened-in porch.

All floors are of cement, painted. Washable rugs are provided for the rooms of the convalescents.

Visitors are not allowed in the building, but there is a narrow balcony running in front of every room, so that parents and friends may come to the patient's window, see and talk with him, and know how he is getting on. This one provision

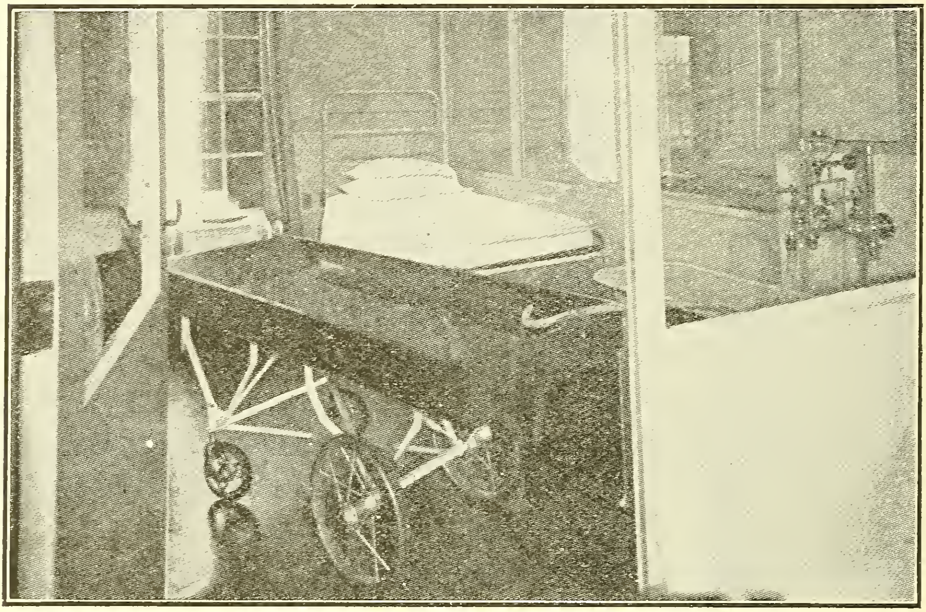


Fig. 25.—View Showing the Arrangement and Equipment of a Single Room in St. Luke's Hospital, Jacksonville, Fla. (*Stevens, The American Hospital of the Twentieth Century. Architectural Record Publishing Co., New York.*)

probably does as much as any one thing to establish confidence in a communicable disease hospital.

The foregoing is a good example of a modern hospital planned on the cubicle system. Desirable features, other than those already mentioned, are separate toilets for each cubicle, making it unnecessary for the patient to leave the isolating room until he is convalescent or discharged, and separate service and entrance from the outside for every room on the ground floor.

By the practice of medical asepsis we are enabled to care for communicable diseases in the general hospital. When this department is in the main building it should be isolated by a fresh air cut-off from the other rooms on the same floor. Separate serving kitchen and sink room must be provided as well as every facility for cleansing the person of the patient, for the work of the nurse and all utilities. The nurse, after thoroughly cleansing her hands and changing the department gown, may mingle freely with the other nurses of the hospital.

Cubicles may be improvised in a general ward or in any building used as an emergency hospital by hanging sheets or other pieces of washable fabric on wires strung between the beds. These not only serve as the barriers delimiting the constructive isolation areas but effectively prevent cross-infection between patients in adjoining beds. The practicability and efficiency of this method has been proven many times, especially during epidemics of the respiratory-borne diseases. It was used in the American military hospitals in France during the Great War and in military, naval, and civil hospitals in this country during the influenza epidemic of 1918. Communicable disease wards formed in this manner are elastic, quickly improvised, readily dismantled, and the screens may be washed and sterilized without trouble and expense after the discharge of the patient.

Plans of the isolation building of Michael Reese Hospital. The isolation building of the Michael Reese Hospital in Chicago may be taken as an example of hospital buildings constructed to prevent cross-infection largely by architectural isolation. The following description of the building and the technic employed therein is quoted from the article entitled "Hospitals for Communicable Diseases" by Mr. Richard E. Schmidt, F. A. I. A., in the *Modern Hospital* for March, 1918.

The building has a basement and two stories and is of fire-resisting construction. It contains four complete units for patients in the first and second stories. The construction is such that the units can be fumigated without damage to the structure.

Food may be passed into the units without danger of conveying the infection to the orderly carrying it, and soiled linen, used dishes, and garbage may be passed out of each unit without danger to those receiving it. Arrangements have been made by which a physician, patient, or nurse may be cleaned up and cleared out of the premises without taking any of the elements of infection with him or her.

Each unit comprises the following rooms, namely: three-bed ward, one-bed ward, patients' bath and toilet room, nurse's bedroom, nurse's bath and toilet, pantry, and sterilizing rooms.

Food, clean linen and other supplies will be brought to the respective porch windows and set upon the shelf of the window so that the nurse can reach it. The soiled linens, used dishes and garbage are to be deposited by the nurse in tanks placed in an enclosed space under the window shelves. These tanks are of galvanized iron and filled with disinfecting solutions. When the nurse desires to deposit soiled linens, she shifts the lid of the tank and drops the linen into it. The orderly can come later, wring out and remove the linens, and take them to the laundry. Soiled dishes are treated similarly.

The physician who has come to examine a patient enters the basement hall and deposits his outer garments in the lounging room, clothes himself in visiting garments taken from lockers in the hallway in the dressing room, and proceeds up any flight of stairs which may lead into the unit he wishes to visit. After the visit he returns to the ground by one of the stairways and removes his visiting clothes in the disrobing room, and if he wishes to visit another patient in the same building he will take other clean visiting apparel from another locker and repeat the procedure as many times as necessary, each time following the same order. When he has made his final visit he removes all of his clothing, takes a shower bath, dons street clothing in the dressing room, takes his outer garments from the lounging room and from there passes out into the street, or back to the general hospital.

It is not necessary to enlarge on the other details which are required for a proper technic.

When the patient and nurse are ready to leave the building they will leave by one of the "porches for patients." The windows leading to these extend to the floor. A separate stairway has been provided from each patient's porch to the ground level. The patient and nurse will separate in the basement exit, bathe and don clean clothing in their respective bath and dressing rooms, and, no longer a menace to the community, leave the building by the doorway marked "exit."

Before leaving the unit the nurse will straighten up preparatory for subsequent fumigation and disinfection. In this procedure, as in the one for patients, there are many details of technic which it is not necessary to describe herein.

The service porches are intended for communication between the kitchen, laundry, and other service.

Electric fans are provided in the nurse's clean-up department in the basement, so that she may dry her hair rapidly. If the patient is a child unable to disrobe, bathe, and reclothe itself, the nurse must clean up, and change her garments twice, first to assist the child, and again after having done this and passed it to a clean nurse on the outside.

This technic is cumbersome in the extreme and should only be adopted when nurses who have been trained or who can be trained in medical asepsis are not available.

Tuberculosis Hospitals. The problem of the care of patients afflicted with pulmonary tuberculosis is different from almost every point of view from that of the treatment of the general medical, communicable or surgical patient. Tuberculous patients are divided into grades according to the progress of the malady and different care is required for each grade.

If the tuberculosis hospital or ward is to be situated on the grounds of a general hospital, then a portion of the site should be selected remote from the other patients' buildings, but with equal regard to sunlight and protection from the cold winds. If the hospital or sanatorium is to be isolated and an institution by itself, and the site selected remote from water, sewage, and other municipal service, the problems are vastly increased, and the natural contour, the nature of the land, and the meteorological conditions must be borne in mind.

If the hospital is intended for all gradations of patients, it is necessary to estimate on about fifty per cent. being of the ambulatory class, who are able to be up and about and able to do light work. Ground must be provided for exercise and recreation, buildings for dining, entertainment and for light industrial work, and facilities must be provided in the wards for the hygienic supervision of the daily life of the patients. The three cardinal principles that should govern the construction of tuberculosis hospitals are provision for absolute ventilation and the admission of the maximum amount of sunshine and fresh air. The outlook and general environment are also of primary importance. Depressing scenery and noisy surroundings detract from the value of hospital treatment.

In caring for tuberculosis cases three general groups are recognized, namely, those in the last stages, ambulatory cases, and out-patients. The first class are treated in wards or rooms similar to medical wards or private rooms, proper care being taken for the protection of the nurse and the prevention of the spread of the disease. The wards should not be too large, all the sunshine available should be admitted, and plenty of out-of-door balconies should be provided.

If possible the morgue should be at some little distance from the wards and have an underground connection. The death rate among ward patients is always higher than in other parts of the hospital, therefore if bodies can be removed in an unobtrusive manner these patients will be saved much mental anguish.

Proper sleeping quarters, with due regard to the out-of-door treatment, must be provided for the ambulatory patients. There must also be dressing and bath rooms which can be warmed in cold weather, recreation rooms for stormy weather, recreation parks for pleasant weather, and light employment for certain hours. A well lighted, ventilated, and heated closet or cupboard should be provided for every ambulatory patient. It should be not less than three by four feet in size, and should contain a seat, shelves, mirror and other conveniences. The mental effect of the possession of such a place that he may call his own is most beneficial to a lonely tubercular patient far removed from family and friends.

The toilets should be reasonably near the sleeping quarters and should be sufficient in size.

It is important that the living or day room should be as light and cheerful as possible.

The sleeping quarters may be in wards amply provided with windows which can be opened, or the patients may sleep in small huts, shacks, cottages or tents, open toward the south, with the beds to the north. The latter is the best and most popular method for incipient cases, for the bed can be brought practically into the open. The southern side can be closed with swinging sash or cloth screens or can be left entirely open.

The out-patient clinic of tuberculosis hospitals and sanatoriums is an increasingly important feature of these institutions. The patients spend the day on the sunny lawns and recreation grounds, where they receive nourishing food and good advice for home living. Steamer chairs, blankets, serving kitchens, and intelligent attendants are necessary equipment for this work. It is through the out-patient clinics that the social service is accomplishing such important results.

The working ability of the ambulatory patients is utilized to advantage in the large county and city institutions. Among other forms of employment and industrial work suited to tubercular patients under treatment may be mentioned waiting on the patients' tables, light janitor work, repairing patients' clothing and repairing linen and making up new material, leather work, carpentry, and general repair work.

According to the size, location, and resources of the hospital or sanatorium, the following should be provided: general assembly rooms for religious and secular services, recreation rooms, reading rooms, store and post-office, general examining rooms, surgical operating facilities, dental room, barber shop, etc.

It is exceedingly important that ample provision be made for the destruction by fire of sputum cups, gauze and dressings that have been used by or in connection with tubercular patients. A suitable incinerator may be installed in a separate building where the patients can deliver their sputum cups and receive fresh ones.

A desirable feature of hospital grounds is the open air shelter or shack in which even the very sick patients may spend the entire day.

Chapter IX

ISOLATION AND QUARANTINE

Isolation

Isolation is one of the oldest rational methods of checking the spread of communicable diseases. The ancient Hebrews used it with good results, and it was probably the means of controlling the leprosy so prevalent in Europe during the Middle Ages. Theoretically it is the most effective single method at our command, but practically the results are frequently unsatisfactory.

Soon after the recognition of the pathogenic bacteria great hopes were entertained that the communicable diseases would be "stamped out," and many hospitals for contagious diseases were built. Smallpox greatly decreased, cholera was controlled, plague was confined to the Orient, and typhus was very rare. This seemed to indicate the early disappearance of the exanthemata, diphtheria, and typhoid fever, as it was assumed that if every case could be isolated until free from infection the diseases would be exterminated. In the light of the imperfect knowledge of that day this confidence was not unreasonable.

It is now known that many factors control the value of isolation in each disease, and sometimes in each case. Some of these factors are modes of transference, degree and duration of communicability, possibility of early diagnosis, and the existence of carriers, missed and latent cases. A knowledge of these factors makes clear the reason for the frequent failure of isolation and indicates the degree of isolation necessary with the different infections.

In chronic infections, such as tuberculosis with open lesions, isolation in sanatoria is the ideal procedure, particularly with careless and ignorant patients. The mosquito-borne diseases may be isolated under a mosquito net. Diphtheria and scarlet fever may be isolated in a general ward, provided general asepsis is practiced. Smallpox should be more thoroughly isolated by reason of its high degree of communicability. The same rule applies to measles. Smallpox cannot be controlled without vaccination, as there are many missed cases, and measles cannot be recognized until several days after the onset, which almost nullifies isolation. Typhoid bacillus carriers need not be isolated if they are careful as to personal cleanliness and are not occupied in the handling of food. Carriers explain the failure of isolation in diphtheria and cerebrospinal meningitis. The effectiveness of isolation varies inversely as the number of carriers and missed cases.

Probably in many cases, especially in house isolation, too rigorous measures have been used or attempted. This has led to the concealment of cases and the intentional misinterpretation of symptoms. Less severe measures will accomplish all the results possible. Home isolation requires apparatus for disinfection, special rooms, and intelligent nursing which, as a rule, can be found or procured only in the homes of the well-to-do.

Different procedures are necessary in the different infections. In some a sanitary guard, as in smallpox, is indicated; in others a placard on the house is all that is necessary.

Isolation is most effectively carried out in hospitals, sanatoria, isolation camps, or temporary barracks. Hospitals find their greatest usefulness in relieving the poor and furnishing them better medical and nursing service, receiving cases from hotels and lodging houses, in checking outbreaks in institutions, and for the protection of families where proper home isolation cannot be maintained. Isolation camps and temporary barracks have proved most effective in the care of yellow fever, cholera, plague, and smallpox.

The question of the quarantine of well members of a family, especially school children, largely depends upon whether the disease is conveyed by a third person, and the frequency of carriers and missed cases. Each disease must be a law unto itself, and attending circumstances must be considered. The general rule in scarlet fever is to exclude the well children from school for four weeks from the beginning of the last case. In diphtheria the same rule applies, provided the children show two negative cultures from the throat and nose. No doubt these precautions miss some carriers, but absolute security is impossible.

In a few occupations it is wise to exclude the wage-earners from their work. This is highly essential when communicable diseases affect the families or other intimate and constant associates of workers about milk, meat, and other foods that may transmit infection. The danger is greatest in typhoid fever and diphtheria. Nurses and teachers and possibly barbers, postmen, department store clerks, and car conductors should also be prevented from following their usual work. Office clerks, mill hands, and laborers may, under ordinary circumstances, pursue their occupations. In equity, wage-earners and others who are practically imprisoned during enforced isolation through no fault of their own, and possibly through the fault of the community, should be compensated and their interests safeguarded during this period.

Isolation is most effective in small communities. The chances are better that a first case of a communicable disease will be recognized early in a village or institution than in a large city. Isolation in an extensive outbreak, rural or urban, rarely accomplishes much.

While not entirely satisfactory, isolation nevertheless does reduce, in a moderate degree, the dissemination of the communicable diseases.

Quarantine

The word quarantine is derived from the Italian word *quarante,* meaning forty, having reference to the number of days ships and their personnel, arriving from plague-infected ports, were detained in places selected to prevent the introduction of plague into the port of entry. Venice instituted the first maritime quarantine in 1403, on a small island, to prevent the admission of plague from the Levant.

Quarantine was defined by the late Surgeon General Walter Wyman, U. S. P. H. and M.-H. S. as follows: The adoption of restrictive measures to prevent the introduction of diseases from one country or locality to another. It is apparent that the term has a much broader meaning than formerly. To-day, instead of being a rigid barrier, it is a means whereby persons and things not carrying or in no danger of carrying infection may be allowed to pass, but those known to be infected or likely to be so may be restrained. The least possible delay to travel and commerce is thus imposed.

In addition to maritime quarantine there are interstate quarantine, municipal quarantine, house quarantine, ''shotgun'' quarantine, cattle quarantine, etc.

Maritime quarantine is administered by the Public Health Service, a bureau of the Treasury Department, except in New York. In that city a Public Health Service officer acts under State authority. A few other ports have an additional local quarantine. For efficiency and uniformity, all maritime quarantines should be controlled by a central authority. Maritime quarantine is largely a phase of foreign relations, and as such should be dealt with by the Federal Government.

The Federal Government controls all interstate relations, and this authority includes the supervision of interstate commerce and passenger traffic, railroad and steamboat sanitation, the pollution of streams flowing through more than one State, and interstate quarantine against the communicable diseases. Provision has been made for interstate quarantine only against the six quarantinable diseases. The communicable diseases will never be brought under control by the local or State authorities without the hearty coöperation of the national government.

Maritime Quarantine. With the growth of scientific knowledge concerning the causes and modes of transmission of communicable diseases, restrictive measures are now less harsh and more reasonable and useful. Most of the leading countries, especially England, have adopted rules and regulations aimed to be effective as far as can be expected, and impose the minimum amount of restraint upon commerce and personal liberty. More dependence is being placed upon prompt notification of communicable diseases. With improvement in the sanitation of seaports, the danger of epidemics decreases and the necessity for harsh quarantine procedures diminishes.

The most logical and practical means of avoiding unpleasant quarantine measures is to exercise greater vigilance at ports of departure. This is done by international agreement, at some foreign ports, by officers of the Public Health Service stationed at American consulates. These officers observe, for a sufficient period, those who are about to sail for American ports and who have recently arrived from infected areas and may be in the incubation period of a communicable disease. They also watch the crews of ships carrying immigrants to our ports, in order that these may not be subjected to exposure while in foreign ports. In addition they supervise the sanitary condition of the cargoes. Every American consul makes regular reports of the presence and progress of epidemic diseases in the port in which he is stationed. If, as a further precaution, a careful daily examination of all on board is made during the transit of vessels, commerce and travelers are saved much delay and expense at domestic ports.

In some countries of the Far East the serious communicable diseases are constantly present, but the ignorance, poverty, overcrowding, and religious fanaticism of the natives, and the lack of modern sanitary regulations due to political and other reasons, are almost insurmountable obstacles to their control or extermination. Of necessity, therefore, civilized countries must use the utmost vigilance to protect themselves against infection from the ports of these Oriental countries.

Variations in climate, presence or absence of insect carriers, character of shipping, etc., make it unnecessary or impossible to enforce the same quarantine regulations at all ports of the world or at all ports of the same country. It would be unnecessary to enforce the same regulations against yellow fever at Montreal as at Savannah, since the Stegomyia does not breed as far north as Montreal.

The present Quarantine Regulations of the United States Public Health Service are based upon the Quarantine Law of 1893. They are particularly designed to afford the greatest possible protection to this country against the admission of disease with the least possible detention of incoming traffic.

Quarantine Stations. It is essential for the thorough and prompt inspection and treatment of vessels and persons that all quarantine stations be supplied with modern equipment. It is needless to say that the details of the plants must vary in accordance with the special requirements of each port.

Stations should be located at a reasonable distance from towns and cities and at a point not likely to be encroached upon by their growth. They should be accessible to, yet removed from, channels of commerce.

The equipment of a quarantine station includes the following: (1) Boarding vessels. (2) Boarding station. (3) An inspection place. (4) Anchorages. (5) Wharves and piers. (6) Disinfecting apparatus. (7) Shower baths. (8) Detention barracks. (9) Dining rooms and kitchens. (10) Hospitals. (11) Water-closets or latrines. (12) Water supply. (13)

Crematory. (14) Laundry. (15) Quarters for officers and help. (16) Means of recreation. (17) Laboratory.

Boarding vessels include tugs, launches, and rowboats, according to the location of the station. Launches suffice in land-locked harbors, but sea-going tugs are required where the station is exposed to the full force of the weather. Commerce will not brook delay in the boarding and inspection of vessels. The boarding station must be convenient to incoming commerce, and includes the boat house and crews' quarters. An inspection place must be provided where the personnel of ships may be examined, as this cannot always be conveniently done aboard ship.

Separate anchorages for infected and non-infected vessels are necessary. The one for infected vessels should be convenient to the station, but out of the track of commerce; it should have good holding-ground for anchors. The channels to both anchorages, and, if necessary, their boundaries should be buoyed. The wharves or piers should be long enough and in deep enough water to enable the largest vessels entering the port to lie alongside in at least ordinary weather. Here should be situated a warehouse for baggage and cargo. At some of the stations the steam disinfecting chambers, sulphur furnaces, and tanks containing the disinfecting solutions are placed on the wharves; at others the apparatus is placed on a barge. An additional wharf may be necessary for the discharge of ballast.

The disinfecting apparatus includes appliances for the use of steam, sulphur dioxide, formaldehyde, and insecticides. The houses containing the shower baths should include disrobing and robing rooms. In the latter the suspects receive sterile clothing and their own is removed from the disrobing room for sterilization.

Detention barracks are required only at the large stations where many emigrants are received. Barracks must be provided for the cabin, intermediate, and steerage passengers, and the crew of the ship. The buildings must be subdivided so that the inmates are divided into groups, and intercourse between the groups must be prevented. The sexes must be separated, preferably in two buildings, one for the men and one for the women and children. Dining rooms and kitchens must be provided for the various classes and groups.

The hospitals must contain isolation wards where the quarantinable diseases may be cared for, and separate establishments where suspects and non-contagious cases may receive treatment.

If the dejecta from the water-closets or latrines are received into a sewer, provision should be made for their disinfection before emptying into the sea or a cesspool. If received into vessels, preferably metallic, the vessels should contain a disinfecting solution of the proper strength.

An abundant supply of pure water is absolutely necessary.

All garbage and waste should be incinerated in a crematory. Cremation is undoubtedly the best method of disposing of the bodies of those dead of communicable diseases.

Some means of recreation should be provided for those in quarantine. Moving pictures are of assistance in this direction.

A laboratory is of prime importance in order to make prompt diagnoses and to detect bacillus carriers.

The Bill of Health. The United States Bill of Health is a State Department document, issued in duplicate at ports of departure by American consuls to masters of vessels clearing for American ports. At the port of entry one copy is given to the collector of the port and the other to the quarantine officer.

This paper describes the ship, enumerates the officers, crew, and passengers, gives the sources and character of the water and food supply and the sanitary history of the vessel. It also states the number of cases and deaths from the quarantinable diseases at the port of departure during the two weeks preceding the sailing of the ship.

A fine of $5000 is imposed upon vessels arriving at American continental and insular ports without the bill of health in duplicate. Foreign bills of health are useless at American ports; ships must have them from the American consuls at the ports of departure.

The bill of health was formerly a valuable source of information to quarantine officers regarding the prevalence of communicable diseases abroad, frequently giving them their first information as to outbreaks in foreign ports. Quarantine officers are now kept informed, not only upon sanitary conditions in foreign seaports, but also upon sanitary and health conditions in the more remote localities from which the crews and passengers of incoming ships are drawn.

Inspection of Vessels, etc. Every ship entering a port of the United States is assumed to be in quarantine until free pratique is granted. This is a signed statement from the quarantine officer that the ship and its personnel are free from quarantinable diseases, and that its entry is without danger of conveying them. The master of the vessel must present this certificate or permit to the collector of the port before his vessel can be admitted to entry. While in quarantine, vessels fly a yellow flag, the letter "Q," of the International Code, from the foremast.

Incoming vessels should be boarded without delay in the order of their arrival, though a reasonable preference is given to passenger ships if freighters and passenger-carrying ships arrive about the same time. Ships entering port after sundown must wait until after sunrise for inspection. The attendance of the master should be required, as the information sought must come from him. The inspecting officer carefully examines the ship's papers, including the bill of health, the ship's manifest, and the crew and passenger lists. A note is made of the number of crew and passengers, also any articles of cargo such as bedding, upholstered furniture, second-hand goods, hair, and hides that may require disinfection. Special consular certificates referring to doubtful articles of cargo are investigated.

The inspection of the passengers and crew and the ship itself should now be made. All hands are generally mustered and passed before the inspecting officer. They are counted and each person carefully observed for evidence of disease. Suspects are called aside to be more carefully examined later. If one of the communicable diseases is suspected the temperature of every one on board should be taken. If plague is apprehended, special examinations for buboes must be made. The diagnosis of those cases treated during the voyage is ascertained by reference to the clinical records of the ship's surgeon. Every person carried upon the ship's papers, whether passenger or member of the crew, should be seen by the inspecting officer or his assistant. Any discrepancies between the lists and the actual number mustered must be explained by the master.

In inspecting a ship particular attention should be paid to the quarters of the officers and crew. Their condition is sometimes an indication of the degree of cleanliness of the whole ship. The steerage, galley, etc., should be carefully inspected. If considered necessary the cargo immediately under the hatches should be examined. If the ship is in ballast the hold may be inspected, and the condition of the inner skin, bilges, etc., noted. The chain locker may be examined to see whether the cables have been properly hosed off previous to stowing.

If conditions are found satisfactory, free pratique is granted; if not, the vessel is directed to the proper anchorage and the yellow flag kept hoisted. Further procedures depend upon the nature of the disease against which the vessel is quarantined, the condition of the ship, whether loaded, light, or in ballast, the presence of passengers on board, etc.

Quarantine Measures. While a vessel is in quarantine no one is allowed to leave or board her, and nothing is allowed to be taken ashore, thrown overboard, or brought on board without the permission of the quarantine officer. This applies to food and merchandise.

After disinfection the ship may proceed with a fresh crew while the original crew and passengers are detained in barracks at the quarantine station. It is well for vessels plying between infected and non-infected ports to carry crews immunized by the disease in question, or by one of the viruses or vaccines.

The United States Quarantine Regulations are enforced against the following diseases: cholera, yellow fever, plague, typhus fever, smallpox, and leprosy. Typhoid fever, tuberculosis, and the exanthemata are allowed to land, but must comply with the municipal health laws of the port entered.

The following are the periods of detention of the quarantinable diseases:

	Days
Cholera	5
Yellow fever	5 to 6
Plague	7
Typhus fever	12
Smallpox	14
Leprosy	not admitted

The period of detention is counted from the last possible exposure or from the completion of disinfection.

It is of the greatest importance for the quarantine officers to ascertain whether an infection was contracted aboard ship or on shore. If contracted on the vessel, the vessel is assumed to be infected. If a case of a communicable disease occurs on shipboard within the period of incubation, counting from the time of leaving port, it is probable that the infection was contracted on shore before leaving port. If it occurs after a longer time from port than the period of incubation, and especially if other cases appear, the vessel is doubtless infected.

The procedures necessary to rid a ship and its crew and passengers of communicable disease depend upon the cause of the given disease and its mode of transmission.

Cholera. The passengers and crew are landed at the quarantine station and segregated in small groups. The sick are removed to the isolation ward of the hospital. Persons from the compartment of the ship in which cholera has appeared are bathed and their clothing disinfected before being sent to the detention barracks. The dejecta must be thoroughly disinfected. A careful bacteriological search is made for carriers, and the feces of all cases of diarrhea is examined. Suspects should be placed in special wards pending diagnosis of their cases.

The water supply and food of the station must be carefully guarded and flies kept from persons, dejecta, and food. The compartment infected and the articles exposed, including baggage, are disinfected by appropriate methods. There is little to fear from the cargo.

Water ballast from an infected port is required to be emptied at sea and replaced with sea water. If this has not been done the ship must proceed beyond the 3-mile limit and comply with the regulations. The water tanks and water are purified by the chlorinated lime method.

The greatest care must be exercised by quarantine officers and employees to avoid contracting or transmitting the disease. Eating, drinking, and smoking aboard the infected vessel must be prohibited, in order to avoid mouth infection. The protection of the hands is of great importance. Rubber gloves and stiff-backed rubber overshoes, which can be removed without using the hands and which can be disinfected by boiling water, should be worn by those working on a cholera-infected ship.

The question of detaining the cabin passengers in barracks must be decided in each case on its merits. Much depends upon the presence or absence of general infection, the apparent source of the infection, the presence or absence of suspicious cases in their part of the ship, and the facilities that exist for maintaining a sharp line of demarcation between the cabin and the steerage.

Smallpox. Ships with smallpox on board, but on which the proper precautions, including isolation of the cases and the vaccination of all persons exposed, have been taken, require only the removal of the sick and the disinfection of the presumably infected compartments and the baggage and other articles exposed to the infection.

If the proper precautions have not been observed, as on freight vessels carrying no surgeon and having no special provision for the care of the sick, it is reasonable to assume that there has been a general exposure of officers and crew. In such a case the personnel must be subjected to some form of observation unless there is positive evidence that they have been successfully vaccinated just previous to the appearance of the disease. The officers, being considered responsible, may be allowed to proceed to the dock with the ship, and there undergo a careful daily medical examination. The crew must either be detained at quarantine or subjected to some arrangement that will insure their daily inspection at some other place during the period of incubation.

It is seldom necessary to detain cabin passengers because smallpox has appeared in the steerage or among the crew. Neither is it necessary to detain the fire and engine room forces because of smallpox among the stewards. Smallpox rarely occurs in the cabins. If a case is found on arrival at quarantine the patient should be promptly removed, and his clothing, effects, and compartment disinfected. No general disinfection of adjoining compartments, saloons, dining room, etc., is necessary. There should be some special reason for holding the other cabin passengers at quarantine. In some instances it is well to notify the health authorities at the homes of the passengers exposed and request that they be kept under observation for the required period. This applies to members of the patient's family, friends, and others who have been in close contact with him.

The treatment of the crew of a vessel on which smallpox has appeared among the passengers must in each case be decided by the quarantine officer. The exposure is apt to be confined to the stewards and stewardesses, some of whom may have attended the patient. The quarantine officer must be guided in his decision by the protection which they have received by vaccination, by the location of their living apartments, and by the willingness of ship's surgeon and the company to be responsible for the care of the suspects.

When a ship is quarantined for smallpox, those who have had the disease and those who show positive evidence of a recent successful vaccination are not usually detained. All others are vaccinated and then released except those who refuse to submit to vaccination; these are detained for the full period of fourteen days.

Plague. Precautions against plague should be begun at the port of departure. All who come from infected districts should be detained under medical observation for seven days, and careful supervision should be maintained over the crew as to the places visited by them while in port. All practical means should be employed to remove rats from the ship before loading it, and to prevent others from reaching it.

If a vessel arriving at quarantine from a plague-infected port has been eight days or more at sea and all on board are well, as shown by a thorough inspection, it may be assumed that neither human nor rat plague exists on board, and the entry of the ship is without danger to the port.

The crew and passengers of ships from plague-infected ports should be most carefully inspected. This includes the taking of the temperatures of all on board and a special examination for buboes. Mild and ambulant cases should be looked for, and those suffering from severe bronchitis or pneumonia should be subjected to a bacteriological examination to determine the presence or absence of the pneumonic type. The sick are sent to the isolation wards and the others segregated in small groups. All who have been exposed are bathed and their clothing disinfected. If no suspicious cases are found among the officers they may be allowed to remain on the vessel and be examined daily at the dock. The crew should be detained at quarantine for the period of incubation of the disease. The detention of cabin passengers depends upon the probable origin of the disease, their destination, responsibility, etc.

The rats, mice, fleas, and other vermin must be killed and incinerated. Sulphur dioxide is usually employed, but hydrocyanic acid gas or carbon monoxide may be used. Rats must not be allowed to escape from quarantined ships. The vessels should be anchored far enough out to prevent their swimming ashore. If moored to the pier the lines must be guarded by inverted metallic cones or kept freshly tarred to keep the rats from reaching the dock by this route. If the searchlight is kept turned on the hawsers the rats, disliking intense light, will have less tendency to leave the ship. The gangplanks should be pulled in before dark. Ships stopping regularly at plague-infected ports should be provided with sulphur furnaces, in order to kill rats at sea.

All trash, including deck sweepings, should be burned in the furnace, not the galley. Nothing should be thrown overboard.

A plague-infected vessel must be given a preliminary, simultaneous disinfection with sulphur dioxide and its further disinfection conducted in a fractional manner. A portion of the cargo, not exceeding 4 to 6 feet, is removed, placed on lighters, exposed to the sun, and carefully examined for rat nests. The holds are then closed and the empty cargo spaces fumigated with sulphur. This process is repeated until all the cargo is removed.

Vessels running to dangerous ports should carry crews composed of men who have had plague or who have been immunized with anti-pest serum.

Yellow Fever. The treatment of yellow-fever-infected ships is limited to measures directed toward killing the mosquitoes on board and to the prevention of their breeding. A ship is considered infected with yellow fever if it has on board cases of the disease or mosquitoes of the genus *Aëdes calopus,* which may have bitten persons infected with yellow fever in port or during transit. If *Aëdes calopus* are on board and a case of yellow fever has appeared within three or four days, these insects must be regarded as infected unless the greatest vigilance has been exercised to screen the patient from their bites. If the vessel has sailed from a yellow-fever-infected port and *Aëdes calopus* are on board, these mosquitoes are presumably infected; furthermore, if the voyage has lasted twelve days or more, they are capable of transmitting yellow fever.

Ships coming from an infected port are fumigated and detained at Atlantic ports south of the Chesapeake and at Gulf ports during the yellow-fever season, usually from May 1 to October 1. This is done as a precautionary measure, even in the absence of cases on board.

If the disease has appeared, the vessel is detained six days following fumigation. Five days, the usual incubation period, is long enough if no cases have occurred on board.

The sick are easily isolated with mosquito nets, and should not be moved if too much exertion is required of them. This is harmful to yellow-fever patients.

The mosquitoes on board must be killed with an insecticide.

Sulphur dioxide is in general use, but it may be desirable to use pyrethrum in the cabins. The disinfection of personal effects and merchandise is absolutely unnecessary.

Wooden ships more frequently carry yellow fever than steel ones, as the former use water casks—ideal breeding places for *Aëdes calopus.* The drinking water of steel ships is stored in metal tanks, safe from mosquitoes.

A careful search must be made for the breeding places, such as fire buckets, water casks, and any fresh water where the eggs may be laid and developed.

Typhus. Quarantine measures depend upon whether the case has been properly isolated and upon the sanitary condition of the ship, especially as regards the presence of lice. If the case has been properly isolated and the ship is biologically clean, there is little or no danger of the further dissemination of typhus. After fumigation with one of the insecticides the ship, crew and passengers may be released. If the case has not been isolated, or if the disease has spread aboard the ship, or if the ship is vermin-infested and in otherwise bad sanitary condition, all who have been exposed must be held at quarantine for the full period of incubation, and the vessel thoroughly fumigated with one of the insecticides.

Leprosy. Alien lepers are not permitted to land in the United States. They must be returned on the same ship on which they arrive, in the meantime being held at quarantine to await the sailing of the vessel on the return voyage. American lepers cannot be excluded, but they are immediately subject to the municipal and State health laws of the city and State in which they land.

Chapter X

MILITARY SANITATION

In a manual of this character a general dissertation on military hygiene is out of place. It is presumed that the reader is more or less familiar with military conditions as well as with the general principles of hygiene and sanitation. This chapter will, therefore, be devoted to a description of those procedures necessary to prevent and check the communicable diseases under the various conditions of military life.

Contact Infection. As in civil life, this mode of infection is the most important, and to minimize the ever-present danger it is necessary that officers and men practice conscientiously the principles of personal hygiene, and that posts, barracks, camps, and trenches be kept in as sanitary condition as the exigencies of the service and prevailing military conditions permit.

The venereal diseases are the most perfect examples of disease dissemination by contact, and in times now happily past almost invariably headed the army morbidity tables, especially in times of peace and during periods of military inactivity. Government reports show a most wholesome improvement both in the American Expeditionary Forces in France and in the forces training in this country during the recent war. A number of factors helped to bring about this favorable condition. The moral, intellectual, and physical standards of this army were very high. With the possible exceptions of Cromwell's Puritan Ironsides and the Crusaders, no military force was ever so well cared for in a spiritual sense; successful efforts were made to keep the men in close touch with their homes by correspondence; wholesome amusements and recreation were provided at the camps and cantonments; the state governments were required by the Federal Government to clear the vicinity of army posts, forts, camps, and cantonments of vice in every form, especially public and clandestine prostitution. The men were carefully instructed as to the dangers of venereal infection, and their pay was stopped while they were on the sick report with a venereal disease. The Federal statute prohibiting the sale of intoxicating liquor to men in uniform had a most beneficent effect in decreasing venereal diseases.

The details of venereal prophylaxis are given in Part II, under the heading "Venereal Diseases."

The overcrowding of barracks and camps favors the transmission of most diseases, including the inflammations of the respiratory passages. Many diseases become epidemic from this cause, especially pulmonary tuberculosis, measles, mumps, coryza, tonsillitis, and cerebrospinal meningitis. Their dissemination is favor by overcrowding, because direct contact infection is greatly facilitated. The same thing is true of typhoid fever, dysentery, cholera, and other fecal-borne diseases that may be spread by direct and indirect contact. Typhus also spreads readily in closely crowded quarters, as intimate contact may permit the infestation of an entire company from a single lousy person.

Sanitarians agree that to afford a proper air space for ventilation without a draught, a minimum of 720 cubic feet per man must be allowed, and that any permanent barracks must be constructed so as to allow at least 1000 cubic feet per man. For the purpose of avoiding contact infection, the amount of floor space allowed each man is much more important than the number of cubic feet. The floor space should never be less than 10 x 6 feet, or 60 square feet, which with a ceiling 12 feet high would afford 720 cubic feet of air space.

Whenever possible the floor space should be 80 square feet, affording 960 cubic feet. It is desirable that the heads of sleeping men should be as far apart as possible.

Although military necessity will frequently make such rules impracticable in the field, in billets, and in some camps, nothing less than stern necessity should cause any reduction in this amount of floor space, for the amount proposed is not a high ideal, but an irreducible minimum for the maintenance of health. Should an epidemic occur and should the soldiers be overcrowded, it may be assumed axiomatically that the epidemic cannot be checked by other sanitary measures alone, but that they must be combined with measures to relieve the overcrowding. (Vedder.)

The perpetual trade in saliva is closely connected with the subject of contact infection. To minimize this danger in camps and barracks Colonel Vedder suggests that the following notice may be advantageously posted in conspicuous places:

To Avoid Spreading Disease

Do not spit.

Do not put the fingers into the mouth unnecessarily.

Do not pick the nose or wipe it on the hand or sleeve.

Do not put pencils in the mouth.

Do not put anything in the mouth without a good reason and never when it has been in another's mouth.

Do not use a common drinking cup. Use your own.

Never cough or sneeze into the air or in another's face. Use a handkerchief.

If the hands become soiled with saliva or nasal secretion, wash them.

If you use another man's tobacco pouch, do not close it with your teeth.

The question of bathing and washing facilities has a most important bearing on contact infection. Barracks, cantonments, and semi-permanent camps are provided with ample bathing facilities, generally shower baths. Lavatories should be provided in the men's toilets of barracks to facilitate the washing of the hands after every defecation and urination. Wash basins should be placed in latrines if possible. During the prevalence of fecal-borne diseases basins of antiseptic solutions should be readily available for the disinfection of the men's hands after visits to the latrines or water-closets. Behind the battle lines in Europe divisional bathing plants were established where large units could be cleansed by hot shower baths in a comparatively short time. In some cases bathing and delousing plants were combined. While the men were being bathed their clothes were sterilized. Several of the contending powers provided railway trains equipped with facilities for bathing, by shower baths, large numbers of men in a very short time.

When billeted on the civil population the ingenuity of troops is called upon to provide bathing conveniences or to amplify those already in existence. Shower baths made from 5-gallon kerosene tins are easily constructed, and are a great comfort to the men in billets or in temporary camps. In the latter and during bivouac the men must frequently bathe in streams, in which case the point selected should be below the place from which drinking water is taken.

In the trenches general bathing is practically impossible, but some simple conveniences for washing the hands and face are available in the dugouts. The British used braziers to heat water for that purpose and for shaving.

Carriers. In the necessarily crowded conditions frequently existing in military life carriers are an ever-present menace, and must be carefully watched for. When large bodies of men are mobilized, it is inevitable that they will include a certain percentage of carriers of each of the diseases spread in that manner. If the whole personnel cannot be examined, especially for typhoid carriers, those who are concerned with the preparation and service of food and the sterilization, care, and transportation of the water supply should have their medical histories investigated and if possible their excreta examined for typhoid bacilli, and they should be kept under constant observation. The same precautions must be taken in regard to the other fecal-borne diseases, especially cholera and dysentery, if there is the slightest reason to fear their appearance in a command. Men coming from districts where the hookworm is endemic should be examined for this parasite, and all cases discovered given careful treatment. The same precautions should be taken with men coming from malarious districts.

In the army men live in closer personal contact than do people in civil life, therefore the detection and isolation of carriers of diseases transmitted by the nasopharyngeal secretions, particularly diphtheria and cerebrospinal meningitis, are much more important. As the men are under military discipline, all carriers can be effectively isolated singly or in units.

Insects and Other Vermin. The malign influence of insects on troops in the field may be very great. Not only is there the ever-present danger of disease transmission, but the men are disturbed and irritated by their stings and bites or even their mere presence. During the course of the recent Great War insects and other vermin were a source of serious concern to sanitary officers. Mosquitoes caused epidemics of malaria in Egypt and Macedonia, lice transmitted the typhus that decimated the Serbian army and civil population, and were potentially dangerous on the Western Front. Flies were very troublesome in France, caused, to a considerable extent, by the dead bodies in front of the trenches in "No Man's Land." Rats infested the trenches and were a source of annoyance and possible danger.

Mosquitoes. The guiding principles governing the prevention of mosquito breeding, the destruction of adults, and protection from their bites are the same under military conditions as in civil life. Systematic anti-mosquito measures were adopted in the vicinity of the army cantonments and camps in the United States under the supervision of the Public Health Service.

The buildings in cantonments and fixed camps should be screened with a net of not less than sixteen strands to the inch, preferably of copper. The mosquitoes in the buildings should be destroyed. They may be searched for with a flash-light and killed by swatters or by the use of a wide-mouthed bottle containing chloroform in cotton. If a dark band be painted on the wall the mosquitoes will usually light on it, and can be very easily found.

Rooms, tents, or dugouts may be cleared of the insects by burning powdered sulphur with the aid of methyl alcohol, or by burning pyrethrum on a piece of tin over a candle, or by heating cresol (about 4 ounces per 1000 cubic feet) in a shallow vessel over a flame until it is vaporized.

In the field as a protection against mosquitoes, especially in malarious districts, individual mosquito bars, head nets, and gloves should be used. When serving under such conditions medical officers should insist that troops be supplied with mosquito bars. The one now issued can be used either on the bunk or in the shelter tent, and in mosquito-infested regions the troops should be ordered to carry them in the field and compelled to use them in the shelter tents.

Malaria prophylaxis by the use of quinine has given good results, though authorities differ in the dosage that should be used. (See Part II, chapter on "Malaria.")

Lice. These are the most loathsome of the insect parasites. They are easily gotten rid of, but military conditions, especially service in the trenches, conduces to early reinfestation. Clean underclothing becomes infested in half an hour. The control of the spread of lice and the louse-borne diseases was one of the most important sanitary problems in the Great War. The main sources of infestation are the man, his clothing and his effects. Vermin may be deposited in bedding and blankets by an infested individual. Lice are not commonly found in dugouts and billets but on the individuals inhabiting them.

The body louse transmits typhus fever, trench fever, and relapsing fever, therefore efforts must be made to reduce to a minimum this important and dangerous accompaniment of army life under what amounts to siege conditions. Delousing is the process of destroying lice and their eggs.

Adequate personal cleanliness of body and clothing is the only preventive or palliative of this pest. The individual can do much to attain this end but military sanitarians must also do everything possible to supply proper bathing facilities and means of delousing the troops by units.

The individual efforts may be summarized as follows: Whenever possible and as regularly as possible the clothing should be searched for the lice and the eggs. Special care during the searching should be paid to the fork of the trousers, waist line, and arm pits. If the removal of the white patch which binds the seams in the crotch does not interfere with comfort, it is well to remove it. Set times should be afforded the men for inspecting their clothes. The periodical inspection by the company and medical officers (at least once a week) to determine the fact of infestation, is of great importance in this connection. The great source of danger is the presence of eggs on the clothing. These hatch in about a week; therefore it is necessary that the trousers especially should be ironed and brushed at least once a week.

Against the lice themselves, the remedies mentioned below are recommended by the best authorities. As a rule powders should not be used in the crotch but down the shirt and trousers. Care should be taken that any powder which falls from the shirt to the crotch should be small in amount, as too much is liable to cause smarting. A man in each unit should be responsible for these preventive measures. Just previous to going to the trenches in the recent war it was recommended that the clothing and body should be treated with the chosen remedies. The preparations were used about every four days. Experiments in the trenches showed that this treatment gave the best results.

The agents found most effective by the British sanitarians for local application were a powder known as "N.C.I." for killing adult lice and a special ointment called "Vermijelli" which has the effect of asphyxiating the young as they hatch out of the ova. "N.C.I." consists of naphthalene, 96 per cent., creosote, 2 per cent.; iodoform, 2 per cent., and is the best all-around vermicide available. One ounce per man per week may be used, dusted on the body or between layers of clothing. "Vermijelli" consists of soft soap 90 parts, mineral oil 9 parts, water 1 part. It is rubbed into the interior seams of the various articles of clothing in the quantity of about 1 ounce a week. The body, from the neck down, may also be anointed with this paste. A method said to be successful is to impregnate articles of underclothing by wringing them out in a solution of 1 per cent. each of naphthalene and sulphur in benzine or gasoline. This is the English "Antiseptic vest" and is not especially irritating to the skin. (McCulloch.)

Any material such as blankets, empty sand bags, etc., in dugouts or billets should be treated with the anti-vermin powder. Old clothing should be removed.

A most efficient method of destroying both lice and their eggs is to subject the clothing for 20 minutes to the action of steam under pressure. A man's entire outfit of clothing must be treated at the same time. In several of the armies engaged in the recent war bath trains were in use whereby from 2000 to 3000 men a day could be bathed and their clothing disinfected. Reserve clothing for these men to use in the meantime was carried on the trains.

Another efficient method of destroying lice and their eggs by means of heat is the "Hot box" devised by Major Harry

Plotz, M. C., U. S. A. It embodies the principle of the fireless cooker, the heat being supplied by a piece of iron about 3 by 4 by 8 inches in size, which is heated before it is placed in the box. Clothing can be thoroughly deloused in a relatively short time in this apparatus.

Rolling steam field clothing disinfectors were in use in the different armies. The Clayton apparatus, for example, is for sulphur dioxide fumigation. Under some conditions the quick and certain action of hydrocyanic acid gas may be utilized. Old box cars, all openings being sealed, make convenient disinfecting chambers for the service of communicable disease camps and hospitals on railway lines.

An improvised device known as the "Serbian barrel" has been much used and with good results on the British Western Front. The bottom end of a barrel is perforated with holes and the top replaced with a flat metal lid, weighted down so as to fit tightly. Sandbag collars are wound around the top and bottom of the barrel to retain the steam; the whole barrel is then placed over a metal boiler which in turn rests on a brick or improvised adobe furnace having a fire at one end. The barrels with separate boilers are often set in series over a long narrow furnace. A container of 60 gallons capacity will handle 7 blankets at a time. As many as 50 of these Serbian barrels have been used at a time in a divisional bathing plant.

The exclusion of vermin infestation and louse-borne diseases from the United States is of great importance, especially as so many of our troops were vermin infested, and typhus fever and trench fever were so prevalent abroad. The following scheme of delousing was worked out by Major Harry Plotz, and was so effective that not a single case of a louse-borne disease was introduced into this country by returning troops and no infestation was introduced into civil communities by discharged soldiers.

All troops will be detained at foreign ports for a period of two weeks, during which time persons with infectious and epidemic diseases will be isolated and universal delousing will be practiced before embarking. Delousing will be practiced on transports when necessary. All soldiers on transports will be instructed to devote fifteen minutes each day to the search for vermin in their clothing. Universal delousing will again be practiced at debarkation camps in the United States. This will serve as a check on the first delousing.

All sick and wounded will be deloused at the debarkation hospital. An efficient method would be to have the delousing room in association with the receiving ward. With the following method vermin infestation would be prevented from being carried to the wards.

In order that the greatest number of men may be handled in the shortest period of time, it is important to have a rapidly functioning delousing plant. According to the plan here proposed, 260 soldiers and all their equipment can be deloused every hour. The man enters with his barrack bag containing all his clothing. The leather materials, rubber, celluloid materials and money are passed in at the locker room. The man receives two numbered tags corresponding to the number of the locker, and then proceeds to the disrobing room with his barrack bag. All his clothing is placed in the bag, which is tied and numbered with one of the tags, the man retaining the remaining tag. The bag is then placed in the carriage, which is pushed into the steam sterilizer. The sterilizer is 18½ feet long by 5 feet in diameter and is provided with two cars and transfer tracks, so that one car will be unloading while the other is in the sterilizer.

The soldier then proceeds to the hair-cutting room. Before entering, he is inspected for vermin and nits. If vermin and nits are found in the hair of the head, axillary or pubic region, he is passed into the barber shop. If none are found, he passes into the shower room. In the barber shop the hair is cropped with an electric hair-cutting machine. The axillary and pubic hair can be shaved in this room. Following this he enters a shower room, where a bath with liquid soap and warm water is obtained. The soap used is a kerosene soap mixture. A drying room follows, a table being provided for the clean towels and a receptacle to receive the soiled ones.

Provision is made in this plan for a pressing room, as the clothing is wrinkled following steam sterilization. The pressing of garments, however, would somewhat retard the process. The leather material, etc., is reclaimed at the locker room. The floor of the building is made of concrete. Two toilets are provided, one for the dirty men and one for the clean men. All attendants wear the louse-proof suit, which is a one-piece garment covering the shoes and tied about the neck.

With an arrangement such as this, when universal delousing is practiced, there should be no danger of vermin infestation or louse-borne diseases gaining entrance into the United States. (The Importance of the Louse Problem. Major Harry Plotz, M. C., U. S. A., *J. Am. M. Ass.*, Feb. 1, 1919. By permission of the author.)

Flies. Sanitary measures directed against infection by flies may be considered under the following headings:

I. Measures directed against fly breeding.
   1. Prompt disposal of manure.
   2. Incineration of all garbage and kitchen wastes.
   3. Sanitary disposal of human feces.
   4. Disposal of dead bodies.

II. Measures to kill adult flies.
   1. Fly traps.
   2. Fly papers and poisons.

III. Measures to prevent access of flies to food.
   1. Screening of kitchens and mess halls. (Vedder.)

Disposal of Manure. The picket lines should be ditched and cleaned off every day, the scrapings as well as the gross manure being removed. They should be burned over weekly with 1 gallon of crude oil and 15 pounds of hay or straw for each animal. No grazing should be allowed within 2000 yards of a camp or cantonment.

In dry climates manure may be burned by spreading an area not more than 4 inches deep where it will not be crossed by wagons. It is allowed to dry two days and then set on fire. It may be burned in windrows 2 feet wide and 2 feet high, made by throwing off the manure from the tail of a wagon. They are about 8 feet apart, and after drying a few hours they are spotted with oil on the windward side and fired. The next day the wagons straddle the windrows and dump the manure on their ashes. Windrows are raked to cover a narrow space, to prevent burning the feet of animals. In wet weather, especially, it is essential that the windrows be worked over constantly and the smudge kept going by turning the unburned manure over on the smoldering part, but not in such quantities as to smother it. (Ford.)

During the rainy reason, when the amount of manure is large, it may be dumped in piles containing twenty to thirty loads, or over the edge of a ravine, at a point not less than 2 miles from camp. The pile should be distant from a through road, as passing men and animals bring flies into camp. These piles are liberally sprinkled with oil and ignited, or if over the edge of a ravine, the fire is started at the bottom. The manure is consumed, but not rapidly enough to prevent fly breeding. (Ford.)

Various types of manure incinerators are in successful operation. The Panama incinerator consists of a grate made of railway iron about 30 feet long and 10 feet wide with a rail 3 feet high. The grate is supported about 3 feet above the ground by concrete or railroad iron uprights on cement foundations. The rails forming the floor are at right angles to the long diameter. No purchased fuel is necessary. From twenty-five to thirty loads a day may be consumed. This device is more effective than the windrow method, as some larvæ escape when the latter is used.

One plan is to construct a wire frame or grid. This is of any required length, and is made in rectangular basket shape, the bed being 4 feet wide and 4 feet deep and elevated about 2 feet above the surface of the ground. Any kind of wire may be used, such, for example, as that found binding up bundles of hay. The meshes of the trough or basket are about 5 inches square. The bars at the bottom are made to run from side to side rather than longitudinally.

Another type of manure incinerator is a rectangular, open brick pit, built like the former above the ground. Its internal dimensions are from 9 to 10 feet each way, inclosed by a brick wall 9 inches thick and about 5 feet high. Air inlets are arranged below on the sides at the ground level, and are about 15 inches square. Just above these is laid a row of Decauville rails, turned with the flange up and about 3 inches apart to form the grate bed. (McCulloch.)

These devices burn manure quite effectively, especially with the aid of a little kerosene. To save fuel the manure should first be spread on an improvised drying platform, best built of concrete, situated alongside the incinerator. The foregoing types of incinerators should be placed broadside to the prevailing winds, and in wet climates should be covered with a galvanized iron roof.

A device for the use of small commands is a cylindrical incinerator about 5 feet high and 4 feet in diameter, made by wiring together sheets of galvanized iron, which is placed over the junction of two trenches intersecting at right angles. These trenches are 8 feet long and 1 foot deep under the incinerator. Instead of trenches apertures 8 inches in diameter may be made at opposite sides of the cylinder at its base. A few tin cans should be thrown in to form a grate. In such an apparatus both manure and garbage may be burned. Tin cans distributed in the mass facilitate the draught and a little oil materially aids combustion. In wet weather the incinerator should be covered with a sheet of tin. A similar container may be made of mud over the intersection of two intersecting trenches. (Ford.)

In default of incinerators the British method of "close-packing" may be employed. The manure is carted as far as practicable away from camp and piled in a dump on firm, dry ground. A compact rectangular block is the best shape, not over 5 feet high. Each new load of manure should be beaten down tightly with shovels into the sides of the heap and the surface and sides treated by spraying with a solution of borax (3/4 pound to a gallon of water). The whole is finally covered with about 12 inches of earth. The theory is that the heat developed by fermentation in the interior of a mass of this kind will prevent breeding by killing the larvæ. (McCulloch.)

Incineration of Garbage and Kitchen Waste. With proper management much of this may be disposed of in the company kitchen fire, utilizing the solid garbage as fuel. Old tin cans, burned and cleaned out by fire, do not attract flies. Fires should be cleaned of burnt refuse once a day. The fire in the field range can be utilized, but only to a small extent, for the burning of wastes.

The Company Incinerator. The type known as the "rock pile incinerator," developed by Col. P. F. Straub, M.C., U.S.A., has given general satisfaction in the American service. It consists of a bed of rock, level with the ground, 1 foot deep, 3 feet wide, and 4½ feet long, surrounded by a stone wall, 18 inches high, except at one end, which is left open for draft, fuel, and access to the fire. The stone wall absorbs much of the heat which would otherwise be dissipated into space, and enormously increases the evaporating capacity of the incinerator. Large stones (cocoanut size) are much better than small ones; as to composition, any kind will do, but limestone, which disintegrates, and flint, which explodes when heated, are not so good as sandstone. During the rainy season it would be advantageous to raise the rock bed a few inches above the ground and bank it around with earth to prevent flooding. (Havard.)

This model may be simplified without much loss of efficiency. Thus when stones are scarce the banks of the pit may be built up of excavated earth, well packed and tamped, without stones. Where the incinerator is to be used for a few days only and the soil is porous, the depth of the stone bed may be reduced to 8 or 6 inches.

With ordinary care and attention about 1/6 cord of wood per 100 men per day is more than sufficient for the destruction of all slops and garbage. The liquid slops are evaporated by being poured slowly along the sloping walls of the incinerator, frequently, but only a few dipperfuls at a time, while the solid garbage is placed over the firebed, on top of the fuel. When the liquids are excessive it may be expedient partly to evaporate them in a tin boiler. Tin cans and other incombustible material are raked out as often as necessary. It is a good plan to remove the stones making up the floor about once a week, so as to clear the pit of ashes and débris. Cooking on such a rock-lined pit is made relatively easy by means of long-legged spiders. (Havard.)

Rock-pile Crematory. For the use of larger units and where fuel and stones are plentiful and in the absence of special appliances, this is a most efficient crematory for the incineration of garbage and refuse, solid and liquid. It is thus described in specifications from the Office of the Chief of the Quartermaster Corps:

At some convenient location a circular pit is dug, 3 feet in depth and 15 feet in diameter. The bottom to be covered with loose stones to a depth of 14 to 16 inches. On this is built a circular wall to the height of 1 foot above the original ground line, and the excavated earth is packed against it clear to the top so as to provide a sloping approach and thereby prevent surface water from gaining access to the pit. A pyramid of large stones 4 or 5 feet high occupies the center. This feature is essential to provide central draft and steady fire.

The bottom stones receive the liquid portions of the garbage without affecting the fire, and soon evaporate and dissipate them. The solid portions are soon desiccated and become fuel. Care should be exercised to empty the garbage into and not around the crematory. It is desirable to place a few heavy stones along the edge of the pit to serve as bumpers or guards to the rear wheels of carts. Only one man is required to operate this crematory. One cord of wood will consume approximately 4500 pounds of refuse and garbage, including kitchen wastes and slops. It will likewise incinerate manure and dead animals. (Havard.)

The Guthrie Incinerator is about 8 feet long, 2 feet high, and is made of bricks laid in cement which are later banked up with earth. One end is open, the other closed. Over the closed end is erected a Sibley stove, or better, a length of 6-inch tile pipe or a chimney 6 inches square, internal measure. The walls support an evaporating pan made of sheet iron, about 4 feet long, 20 inches wide and 6 inches deep. An overflow hole is provided near the top at one end. This pan may be near the chimney, or if an open space is left between the two this should be crossed by iron bars, on which solid garbage may be dried. A piece of sheet iron on the bars will increase the draft.

Incineration is the most practical, economical, and efficient method of disposing of kitchen and company wastes in the field. The only absolute bar to its use is lack of fuel in a wet climate. Under these conditions some wastes have to be carried away and buried in deep pits. This is seldom necessary, as crude oil can be obtained almost anywhere.

When the supply of wood for fuel is scant, waste water may be disposed of in kitchen soakage pits. Such pits are usually about 5 feet square and 4 to 5 feet deep. The sides and bottom are well broken with a pick. They are covered with boards, or if these are lacking, by boughs covered with earth. A hole is left in the top to receive a snugly fitting, removable box. This has a removable top and a screened bottom made of burlap or mosquito net. The object of this is to strain out the fats, which would quickly prevent absorption of liquid by the soil. The value of the strainer is increased if the bottom be covered with two layers of burlap and over this there be an inch or two of sand. The addition of 5 grains of alum to the first gallon of fluid would form a flocculent precipitate which would impede the passage of fine particles of refuse. Solids and fats arrested are removed and burned on the fire; liquid is usually absorbed by the soil, but may be removed by an odorless excavator. From time to time the sand must be renewed, especially if alum is used. Liquids collected in cans or covered pits near kitchens may be removed by an odorless excavator to a communal pit several hundred yards from camp. In this, septic action occurs. Such a pit may be used several weeks, depending on its size and the porosity of the soil. Flies do not breed in it until the margins are saturated. The pit is then filled with water to drown the larvæ and it is later filled in. Such a pit may be divided into compartments like a grease trap.

A grease trap used in the English service is made by dividing a box into two compartments by a vertical partition which does not quite reach the floor. It leaves an interval about an inch high. The box is filled with sand to a depth of 2 or 3 inches. The side receiving fluid is covered with a removable colander-like receptacle to arrest solids. It may also contain any absorbent material which will arrest fats and which may be removed and burned. Waste water will be freed from fat, as it passes through the sand and under the partition, up into the second compartment, so that it can be absorbed by the soil. It escapes from the box through a notch in the side or through a pipe and goes off into a ditch. It may first be passed through settling tanks before it enters the ditch. Another device is to employ a half barrel as a separating tank. Grease rises and is skimmed away; the fluids are siphoned off. Precipitation of small particles of solids other than fats can be accelerated by alum, 5 grains to the gallon. (Ford.)

Sanitary Disposal of Human Feces. Forts and army posts are provided with sewage systems of the various modern types adapted to their geographical location, amount of water supply, etc., and differ in no way from those in use in civil communities. Permanent camps and cantonments should, if possible, have a water-carriage sewage system. This requires a relatively large water supply, which is not always obtainable. It is the cheapest method of disposing of excrement under such conditions. Incinerators can be used only in permanent camps and cantonments as their cost of installation is high and they are not mobile. In semi-permanent camps deep trenches or pits with some form of latrine box is generally used. For moving commands straddle trenches, knock-down latrine boxes, or improvised incinerators are used. In the trenches on the Western Front various modifications of the pail system were used.

The pit employed for semi-permanent camps or for permanent ones in the absence of sewage systems was 3 feet wide at the top and 2 feet at the bottom and 8, or better, 10 feet deep. Its length depended upon the size of the command it served. From 5 to 8 per cent of the command should be accommodated at one time, and 2 feet of linear space allowed to each man. As usually constructed in the field, where box seats were not obtainable, the pit was slightly wider at the top than at the bottom, and was provided with a seat consisting of a long pole or sapling resting on forked sticks or curved logs about 3 feet beyond the ends of the pit. Each man was required to cover his deposit with earth. The latrine was surrounded with brush or a canvas or burlap screen, and covered with a tent fly or other suitable material.

Whenever possible latrines should be boxed, so as to convert them into close vaults, more easily policed, and from which flies can be excluded. The cost of construction and operation of latrine boxes is so much less than that of incinerators (1-30) while their simplicity, mobility, and quickness of installation are so much greater that, although theoretically inferior to them as a means of excreta disposal, they are to a large extent superseding them, experience having shown that they can be safely and successfully used for long periods of time in permanent camps. (Havard.)

Latrine boxes should be designed according to uniform standards, so that they may be readily constructed wherever needed. They should be light and portable, yet strong and tight-jointed, so as to endure rough handling and exclude insects. The seat holes must be provided with self closing lids, so that they may never be left open, and also to prevent men from squatting on the seat instead of sitting down during defecation. The principal reason, however, for not leaving the holes uncovered is that flies and other insects may not enter. Therefore if flies are absent, as in winter and early spring, and the latrine is sheltered from rain, lids may be dispensed with. (Havard.)

Several types have been advocated. The present tendency of our military sanitarians is in favor of a solid, nailed-together box with a single row of seats. The Manual for the Quartermaster Corps, 1917, contains the plans of a standard latrine box that combines most of the desirable features hitherto recommended. The box rests on a frame and has four seats. It is 8 feet long, 17 inches high, and 22 inches wide on top. The holes are oval in shape 10x13 inches wide. The lid is 14 inches wide, bearing an oval piece beneath, made to fit the hole, and prevented from opening to a right angle by a block nailed to the upper side. A piece of tin 7 feet by 10 inches is fastened by its upper edge to the inside of the front wall, opposite each seat, and set at an angle that causes the urine projected against it to fall clear into the pit.

Good ventilation of the boxed latrine is necessary to favor the work of the aërobic bacteria and thus prevent the production of putrefactive odors. It also helps the evaporation of moisture, preventing its condensation on the under surface of the lid and the edges of the holes. Therefore, the box or its contact with the ground should not be impervious to the air, but simply tight enough to exclude flies. If special ventilation becomes necessary on account of unpleasant odors, it may be attained by a round hole, 4 inches in diameter, at or near the center of the top, guarded when not used by a sliding bed, and admitting a tin pipe 5 to 6 feet high. This pipe should be screened at the top and bear a flange about 6 inches from the lower end to keep it from sliding further down. A pipe of tar paper may also be improvised, with a piece of loose-meshed muslin tied at the top. An efficient and simple method of ventilation is to provide a screened opening 6 by 6 inches in each end of the box.

Special urinals must be provided outside the latrine boxes, as they do not permit direct urination into the pit (except during defecation). The best device is a galvanized iron trough, 6 to 8 feet long, supported by cross sticks. At one end of it is a projecting collar upon which fits the outlet tin pipe. This pipe should run down, under the edge of the box, into the pit rather than through a hole cut through the end of the box. Tar paper or painted muslin are convenient materials with which to improvise urinals and pipes. The urinals should be in the shape of troughs supported on forked sticks or of funnels suspended from tripods. Wooden boxes and gutters may also be available. If none of these materials is at hand, a shallow trench partly filled with gravel must be used. (Havard.)

It is preferable to separate the urine from the feces, as urine or water in latrines interferes more or less with the action of nitrifying bacteria and favors putrefactive decomposition, especially when earth is mostly relied upon for disinfection. This is accomplished by running the outlet pipe of the urinal into a deep hole like a post hole, the lower end of the pipe fitting through an opening in a board covering the hole. A pit urinal may also be used. This can be quickly improvised by digging a circular pit 3 feet deep and filling it a little more than half full with stones, clinkers, ashes, gravel, or loose earth.

For temporary camps, if not lasting more than three or four days, straddle trenches will answer every purpose and pits are unnecessary. The system in use in the British Army is best. The trenches are 3 feet long, 1 foot wide, and 2 or 3 feet deep, each trench being intended to be used by one man at a time. The earth and sod are heaped up at one end, not at the side. The interval between the parallel trenches should not be less than 1 foot nor more than 2 feet. As only one set is contemplated a wider interval is unnecessary. A distance of 1 foot is left between the ends. As a rule five trenches are provided for every 100 men, but three or four per hundred men are enough for commands exceeding 500 men. With a depth of 2 feet and good management a trench can be used three or four days.

Straddle trench covers for the use of marching commands have been recommended. As developed and found most practicable they consist of platforms made by nailing two planks 10 inches apart on four cross-pieces of 2 x 4 timber. The space between the planks is closed in the middle or at intervals, forming two or four openings for defecation. Each cover is placed over a trench 6 or 10 feet long, according to the number of holes. On those having two holes it is well to have one of the lids hinged at the central end of the opening, so as to be interposed between the two men. Each man squats with his back against his lid, and is thus screened from the other men.

The lid is prevented from opening to a greater angle than 85° to insure its automatic closure after use.

The Field Service Regulations of the United States Army require that latrines be placed at the ends of the company street on the side farthest away from the company kitchens. Usually one is provided for each company and one for the officers of each battalion. They should be dug if troops halt for only a few hours. In sites subject to inundation they should be ditched and the edges banked. If dug in sandy soil they have to be provided with retaining walls of timber or revetted with sand-bags.

The policing and disinfection of latrines are most important. The Army Regulations provide for the issue of toilet paper whenever practicable. Great care is necessary in the use of light tissue paper, especially in open latrines, as the least breeze often prevents its falling into the sink, while a stronger wind may blow it up and scatter it over the camp grounds. This is much less likely to occur in boxed latrines.

The open latrine should be in charge of a civilian scavenger or enlisted attendant, permanently detailed if possible and held strictly responsible for its sanitary condition. Every man using it must be required to cover his discharges with earth thrown in with a tin can and not carelessly kicked in. Furthermore the attendant, twice a day or oftener, should make an examination of the contents and throw earth on any part of the surface not properly covered, not neglecting the fecal matter adhering to the walls. When earth is not available lime may be used, but it should be one or the other, not a mixture of both, as the lime destroys the saprophytic and nitrifying bacteria contained in the earth and each ingredient loses much of its efficiency.

The attendant should daily scrub the seat with soap and water and carefully police the edges of the pit and urinals, sprinkling lime wherever fouling has taken place. One of his chief duties should be to see that toilet paper escaped from the latrine is promptly returned to it or otherwise safely disposed of. The easiest solution of this troublesome difficulty is occasionally to light a small open fire, in which all loose paper, caught on a pointed stick, is readily consumed.

Latrines should be inspected by a medical officer at 9 A. M. and 4 P. M. daily. All trenches should be filled in before a command moves.

The disinfection of latrine pits by fire has proven generally satisfactory when carefully performed. One gallon of oil and 15 pounds of straw are required daily for each company latrine. The box should be removed during combustion and the fecal matter stirred into the fire with a pole, this incineration tending to keep the flies away and preventing their laying eggs on the scorched and hardened feces. When oil and straw are not obtainable the ashes from the company kitchen should be scattered in the pits.

Recent experiments have shown that pits may be rendered fly-proof in a simpler and cheaper way by spraying. The method is as follows: When the latrine is first established, the inside of the box and the sides of the pit are thoroughly blackened with a mixture of 1 pound of bone black and 3 gallons of crude oil, by means of a spray pump. The application to the sides of the pit and to the inside of the latrine box is repeated once in ten days. Black is a deterrent to flies, and they will not light on a surface so treated. In addition to the above, the contents of the pit are thoroughly covered each day with 1½ gallons of bone-black mixture, using an ordinary sprinkling can for the purpose. With a reasonably tight box flies will not enter a pit thus prepared. Provided the pit is not used as a receptacle for waste paper and other rubbish, it will not be so quickly filled under this treatment as when burning is resorted to. Another advantage of this method of latrine management is that it is applicable to pits that are shored up with lumber to prevent caving and to those containing water either from seepage or from flooding.

Urinals can be disinfected with lime, but scrubbing with crude oil is more effective.

When a sink is filled to within 18 inches of the top, it should be discontinued and filled up with earth, which should be piled up a few inches above the surface to allow for sinking.

Both the fire and spray systems of latrine disinfection require large quantities of oil, and are, therefore, confined to more or less permanent camps. With a moving command latrine boxes will generally have to be abandoned. Such dry fuel as is locally available may be used without oil, but, as a rule, no other or better disinfectant will be at hand than the earth dug out of the pits. (Havard.)

Special night urinals must be provided regardless of the form of latrine used. At night a tub or can should be placed in each company street, with a red lantern over it, and should be emptied and cleaned out at reveillé. Urine cans are not always available, and the congestion at the latrines after reveillé is such that additional facilities should be provided. The English service employs two trenches, 6 inches deep and 8 feet long, at an angle of 30°, leading into a soakage pit. The disadvantage of this practice is that one side becomes fouled and that urine is tracked into camp. Nested funnels, 4 feet long, 6 inches in diameter at one end and 2 inches at the other, may be used. In their absence tubes made of tin cans can be employed. A pit is dug and filled to near the top with broken stone or tin cans in which many holes have been punched. The funnels or the improvised tubes are inserted into the pit at a convenient height. The pit is then filled up, covered with sod and roped off. The funnels are lightly plugged daily with grass to make them fly-proof.

The American Army have from time to time utilized several types of incinerators for the disposal of feces, but this system, at one time highly praised and extensively used, is not often seen now in our camps. Its cost, difficulty of operation and transportation, and the amount of fuel required are serious objections which are often found to overbalance its advantages, one of which is that incinerators, or destructors, as they are variously called, can also handle other forms of camp refuse which in addition serve as fuel.

The British use successfully the Horsfall and the Meldrum types of destructors, or some improvised modifications of them. The unit or Horsfall portable destructor is constructed of iron walls with firebrick lining. It serves 1000 men if the urine has been previously drained away from the solids into a soakage pit, and at an expenditure of not over 100 pounds of fuel a day. In this type of incinerator the furnace is separated from the bottom of the flue by a baffle plate, thus forming a combustion chamber in which solid excreta are burned. This is the essential thing in the plan of the apparatus, as besides aiding combustion, offensive gases are thus oxidized and made inodorous. Very careful firing and stoking are necessary for its proper working, a supply of one-half fecal matter and one-half other refuse at each feeding giving the best results. The English Sanitary Notes (1916) state that improvised incinerators of the Horsfall type may be easily made with bricks or kerosene oil tins filled with ash and clay and wired together, the important thing being that a proper combustion chamber is provided.

The central or Meldrum type of destructor works on a larger scale and serves from 5000 to 8000 men. Being fixed, and necessarily located farther back from the front than the smaller Horsfall type, cartage of the buckets for part of the distance is required. A drying shelf over the fire is a very useful addition to the fixed incinerator. In these incinerator methods sawdust is an improvement over cresol for use in the pails in which the men deposit the feces.

The foregoing are closed types of incinerators. The open types, while easily adapted to ordinary refuse, are for obvious reasons extremely difficult, if not impossible, of application to the disposal of excreta.

The sanitary trough latrine was one of the results of the investigation by the medical board appointed to determine the cause of the typhoid fever epidemics in our camps in 1898. It consists of a small, well-ventilated frame building containing the trough and urinal. The trough is of galvanized iron, parabolic in cross-section, with sloping bottom. The urinal is a galvanized, rounded steel trough, placed against the rear of the building in line with the latrine trough. It has a fall of 5 inches, and is connected with the latrine trough by a 2-inch galvanized-steel pipe.

When ready for use, water should be poured into the latrine until it has a depth of at least 2 inches at the upper end. Lime was formerly added to the water, but it is now generally replaced by crude petroleum, one quart in the water. It is necessary to empty the trough once or twice a day by the so-called "odorless excavator." This consists of a wagon bed supporting a water-tight tank having a capacity of 500 gallons, and a pumping apparatus mounted on a pair of wheels which track with the wheels of the wagon. The contents of the troughs are pumped through hose into the tank.

The sanitary trough latrine is very convenient for the men. It may be placed closer to the tents than the pit latrines. Flies are less attracted than by open sinks, and, if lids are used, can be entirely excluded. On the other hand, the system requires heavy and costly material, and is applicable only to cantonment and permanent camps. In favorable situations it may be possible to place the outlets of the troughs directly over sewer manholes. The system is useless in very cold weather with the temperature below the freezing-point. Water and oil or lime are necessary, and the question of the final disposal of the excreta may be troublesome. The place of final disposal may be a sewer, the sea, an incinerator, or a burial pit. If crude oil is used to cover the surface of the liquid in the trough, the tank wagon may even discharge its contents upon the surface of the ground, as the oil keeps flies away and acts as a deodorizer. (Keefer.) The heavy-wheeled excavator may become useless in sandy or muddy roads. It is the consensus of opinion that wherever the trough latrine can be used incinerators will be found equally practicable and more efficient.

In some camps and army posts, especially in the Philippines, the earth closet latrine has been used to advantage. It consists of the same type of building, row of seats, and urinal as the trough latrine, but instead of a trough there is under each seat a galvanized steel box, 18 inches wide, 14 inches deep, 21 inches long from front to back at top and 18 inches at bottom, the rear end being vertical and the bottom corners rounded. When the specified boxes are not available empty kerosene cans serve the purpose very well. Each box or can slides out through a corresponding door upon a platform of joists extending 2 feet in the rear of the wall. The contents of the boxes or cans are disinfected with earth or lime. If lime is available, the boxes, before being used, are filled about one-fourth of their depth with milk of lime. The addition of a small quantity of crude carbolic acid forms a very effective disinfecting mixture. The boxes are taken out as often as necessary, emptied, washed, and replaced. In cold countries, or wherever there is danger of freezing, dry earth or lime is used.

The earth used should be the sweepings of roads, properly screened, or the top soil, sun-dried and pulverized. If kiln-dried, the nitrifying bacteria upon which its action depends would be destroyed. Sand, ashes, and sawdust are more or less sterile, and should only be used when nothing better is at hand.

The Disposal of Excreta in the Trenches. This is an important and difficult problem. The use, under any conditions, of pits, buckets, etc., in front-line trenches leads to disagreeable and insanitary results, and such attempts heretofore made for the sake of convenience have been abandoned.

The British found a practicable solution in the employment of bomb-proof pits or dug-outs leading out of the communication trenches. The best method, and one that is practicable in most cases, is to use in the pits individual buckets or tins with improvised handles, enclosed in simply constructed fly-proof boxes, or at least in boxes having a fly-proof lift-off seat that will fit closely on the top of the pail. Lids should be self-closing. The pails, when about two-thirds full, are replaced by clean ones and are carried back for final disposition of their contents. Fresh buckets are filled about one-quarter full with dilute cresol solution (1-360) after the internal surface has been rubbed with crude oil, when this is available. In some cases, especially when incineration of the contents of the buckets is contemplated, sawdust instead of cresol to a depth of one-quarter or one-third, is employed, and the same material added by a scoop after each act of defecation. One hundred pounds of sawdust per regiment per day will suffice. Whenever spillage occurs during removal, the soiled area should be treated at once with a 5 per cent cresol solution. Whenever possible to provide it, a concrete floor for the bomb-proof pit is a great improvement. Bomb-proofing in this connection usually means simply a sufficiently thick layer of earth between the roof of the excavation and the surface of the ground.

It naturally adds much to the efficiency of this system if the urine can be handled separately, particularly if the final disposition of the discharges is by incineration. This is done in some cases by separate urine buckets, in others by soakage pits such as have been described.

The upper and under surfaces of the box seats should be swabbed with cresol after being cleaned. The cleaned buckets, cresol solution, sawdust, toilet paper, and other necessary materials are stored in a bomb-proof dugout situated off the communicating trench, conveniently near the bucket and urine pits.

As to final disposal, the buckets are carried back by hand and (1) buried, (2) incinerated in destructors, or (3) emptied into deep trench latrines. In any case the buckets are at once cleaned, best over a concrete washing platform with the aid of dilute cresol solution, followed by the use of dry sawdust and a stiff brush.

In disposition by burial the contents are emptied into a quartermaster's sanitary cart (*Anglicé trumbel*) and carted away to the reception area, where they are trenched into the ground daily and covered with not less than 12 inches of earth. Urine and sullage water should be treated separately by first passing it through a sedimentation tank, and then irrigating it out through wooden or earthenware channels onto furrows on the land selected. Pools should be avoided by feeding out the effluent as evenly as possible. The areas treated in this way are with difficulty kept in a sanitary condition with regard to flies and in thickly inhabited districts are often hard to find available. (McCulloch.)

Wherever practicable the British select the method of incineration in some form of destructor as the method of choice.

Disposal of the Dead. From a sanitary standpoint cremation is undoubtedly the best method of disposal of the bodies of the dead, but it is probable that public sentiment in this country and Great Britain would not permit of its adoption. It proved practically satisfactory in Manchuria and was used by the Germans in the recent war. Alternate layers of corpses and wood were piled upon huge stone cairns, the whole mass saturated with tar and kerosene and lighted. (Lelean.)

For the burial of the dead on the battlefield, a pit with sloping sides 35 feet long and 7 feet wide at the bottom and 6 or 7 feet deep should be dug, and around the bottom a small trench should be made, draining into a well at the lower end, both the trench and the well being filled with stones. Good drainage and absence of water facilitates oxidation and prevents putrefaction, for which reason the bodies should be stripped of outer clothing. They should be laid across in three or four superimposed rows, the rows being separated by brush or straw. The pit is then filled with earth, which is piled above the ground into a convex or ridged top capable of shedding the rain. The greater the number of bodies buried together the more rapid will be their disintegration.

In selecting sites for pits, care should be taken that they do not drain into nearby water courses that may be used as a source of water supply.

Identification tags are not removed from the dead, but left on the bodies when interred. Tags found on the enemy's dead are collected and turned over to the commander of trains, who sends them to the provost marshal at the base. (Vedder, F.S.R., 1914.)

The Disposal of the Carcasses of Animals. This subject is important, not only because of the myriads of flies bred in the dead bodies, but also because of the fearful stench emanating from the carcasses. They are usually buried, but the labor involved in the burial of a dead horse is more than appears at first sight. One most convenient method is a combination of burial and burning, in which a hole is dug beside the body, which is then disemboweled and the viscera buried and well covered. The carcass is dragged over the buried viscera and blood-saturated soil. Over the cœlom and over the surface there is distributed 30 or 40 pounds of dried grass or litter, which is soaked with a quart of kerosene and set on fire. The method aims at sterilization of the surface and not at incineration. If the work is done before the saprophytic organisms have had time to penetrate any but the very superficial tissues, the result is that the whole exposed surface is sterilized and so charred that it affords no attraction for flies. Further, the method also achieves the purpose of sterilizing the soil, which has been fouled by blood, possibly highly infective. This is of the utmost importance when the animal has died of an infectious disease due to sporing organisms, such as anthrax or tetanus. In dry climates—such as South Africa—it will be found that the carcass so treated shrivels and undergoes what was formerly known as eremacausis, which causes no offense.

No carcass should be buried without slashing the intestines freely, so that gases may escape and not force open the covering earth so that flies can breed in the exposed corpse. (Lelean.)

Measures to Kill Adult Flies.—*Fly-Traps.* These are constructed on the principle that flies are attracted through the dark opening at the bottom of the trap by the sense of smell. After feeding they attempt to leave by flying toward the light, and so enter the trap. Traps must, therefore, be raised a sufficient distance from the ground to allow the flies free access, and must always be baited with some attractive, odorous substance. Flies will not enter a trap that is not baited properly, but in spite of this fact in many camps traps have been left without bait. An old decaying fish head or one of the following solutions make excellent bait: Molasses one part to water three parts; brown sugar one part to water four parts. These solutions are more attractive after they have fermented. Vinegar and sugar or sour milk may be used.

Fly traps are usually made of wire net, are about 2 feet 6 inches long, 1 foot wide and 16 inches high. There is provided a reëntrant prism, also made of net, which should be nailed at its base to the side bars of the frame so that it covers the trap's entire area, less the thickness of the wood strips. This prism should be about 8 inches high, and its sides should slope to give an angle of between 70° and 80° at the ridge. Apertures not more than ½ inch in diameter should be made by forcing the threads of the wire apart, and not by cutting it. They should be about 2 inches apart. When no wood is available for frames the traps are made in a generally cylindrical shape, closed at the side and along the top by wire from hay bales. The legs of traps should be not more than 1 inch long. Traps may also be made of kegs, boxes, tin cans, etc., by removing tops and bottoms and leaving short projections to act as legs. The top is covered with net and the bottom provided with a reëntrant cone, prism, or pyramid of wire net.

Fly Paper is fairly efficient, and may be made by heating together five parts of castor oil and eight parts of resin, by weight, until it is stringy; when cool it is painted on glazed paper. The mixture should not be brought to the boiling-point. The fly paper is hung to advantage from the ridges of cook tents, or the mixture may be painted on wires which are hung on latrines or strung across mess tents. (Lelean.)

Fly Poisons are very efficient and safe when properly prepared. A good fly poison should be attractive to flies, for it may be assumed that there are alternative drinking places. Formaldehyde in a concentration of 0.5 to 1 per cent is attractive to flies and is more efficient than any other fly poison. Sodium salicylate in 1 per cent solution is almost as efficient, and is easier to keep and handle. A formaldehyde solution of 1 per cent corresponds to 2.5 per cent of the 40 per cent solution sold as formalin. If accurate solutions cannot be obtained, use 3 teaspoonfuls of 40 per cent formaldehyde to the pint of water, or 3 teaspoonfuls of powdered sodium salicylate to the pint.

Nearly fill a glass tumbler with the solution, place over this a piece of blotting paper cut circular and somewhat larger than the tumbler, and over this place a saucer. Invert the whole device and insert a match or toothpick under the edge of the tumbler to permit access of air. The blotting paper will remain in the proper moist condition until the entire contents of the tumbler have been used. A very little sugar sprinkled on the paper may increase the attractiveness of the poison for the flies, but care should be taken not to use too much. These poisons kill flies in a few minutes after drinking. Flies drink best early in the morning, and the poison should be set at night so that it will be ready. (Vedder.)

Flies that have gained access to kitchens or mess halls may be killed by swatting, but this is the poorest method of killing flies, and indicates that other methods are not being carried out efficiently. If fly breeding is controlled, if fly screening is effective, and poisons and traps are used to kill the few flies that enter the kitchen and mess hall, there should be little opportunity for fly swatting, a method that is time consuming and inefficient. (Vedder.)

Measures to Prevent Access of Flies to Food. In the field this is a most difficult measure to carry out, and can be applied only in garrisons, forts, cantonments, and permanent camps, where buildings are available both for cooking and messing. It has been demonstrated abroad that our former plan of screening entire kitchens can be improved on by substituting the screening of the food itself. Screened cupboards or safes are used for meat, opened or other foods that attract flies, especially those that are not cooked before eating. Simple muslin squares, weighted at the corners, can be used for much of this work. Eating utensils are also kept covered. Covered barrels or tins are employed for the bestowal of refuse previous to incineration.

While the screening of kitchens and mess halls is not considered as necessary and efficient a measure as it formerly was, nevertheless it is deemed desirable in permanent camps, cantonments, billets, etc. The details differ in no way from the same work in civil communities.

Fleas. In regions threatened or infected with plague the destruction of fleas is important. In barracks, cantonments, etc., they may be destroyed by scattering flaked naphthalene on the floor and closing the doors and windows for twenty-four hours. Saturating floors with an emulsion in water of 5 per cent cresol, with or without the addition of 20 per cent of soft soap solution, gives excellent results. Kerosene and miscible oil are extremely efficient pulicides. Floors and the ground under the houses may be thoroughly sprinkled with kerosene, and the posts supporting the houses may be smeared with crude oil. The fumigants, bisulphide of carbon, hydrocyanic acid gas, and sulphur, are highly effective agents for the destruction of the insects.

Fleas may be dealt with on the body by pyrethrum powder, which must be fresh, oil of pennyroyal, which has considerable value as a repellant, and by iodoform sprinkled on the clothing.

Bedbugs. Bedbugs infesting billets, cantonments, etc., can be destroyed by successive fumigations at three-day intervals, as the eggs may not all be destroyed by a single fumigation. The agents most useful are sulphur, 1 pound to each 1000 cubic feet of air space; pyrethrum, 5 ounces per 1000 cubic feet; or camphor and phenol, equal parts, 4 ounces per 1000 cubic feet. If fumigants are not available, employ a spray of benzine or gasoline or paint surfaces with a 25 per cent emulsion of petroleum in water. Infested clothing or bedding should be steamed.

Cockroaches. Cockroaches may be destroyed around a kitchen or mess room by dusting the floor with sodium fluoride, either pure or diluted one-half with flour or gypsum. Other useful powders are borax, either pure or mixed with pulverized chocolate in the proportion of 1 to 3, and pyrethrum. A sweetened flour paste containing 2 per cent of phosphorus to 98 per cent of glucose and flour is used. They also succumb to the fumigant insecticides, including pyrethrum.

Rats. Measures for the destruction of rats have been given in the chapter on "General Prophylaxis," and these may be adapted to military conditions. They are briefly as follows: Removal of food supplies; elimination of habitats; destruction by natural enemies, traps, and poisons. Since rats thrive on human food and garbage, all food containers should be rat-proof and all organic waste destroyed.

Rats have been very troublesome in the trenches. They may be reduced to a minimum by using the greatest care that there is no food left for them. All débris must be collected in bags and carried to the rear at intervals. They may be killed by various rat poisons, traps, or terriers may be taken into the trenches.

Water. The provision of an adequate supply of potable water in the various and rapidly changing conditions obtaining in military life is ordinarily a very difficult matter. More or less permanent garrisons, cantonments, and camps resemble in a general way permanent civil communities, and when near cities the water supply may be obtained by extending the systems already in operation, and the methods of water purification used in cities may be utilized.

In temporary camps the problem is much more difficult, as the existing supply of pure water is generally insufficient for the suddenly increased population of a district. The use of water from more or less polluted streams, therefore, becomes unavoidable, special methods of purification being necessary. The method selected must be of adequate capacity, must be reliable, and must be easily and quickly installed.

During marches the location of commands changes frequently, and as there is scant opportunity to select the source of water supply, any available water must be used. The water carried by the men must be sterilized or purified by an easily applied method. As a rule, this is done in camp, and must be carefully supervised. In the presence of the enemy it will frequently be impossible to employ even the simplest methods of purification. Such methods as are used must of necessity be carried out by the individual soldier or by small units. Little or nothing can be done to protect the source of supply, and general supervision of efforts to purify the water is impossible.

The methods of purification vary in cost, availability, ease of application, and time involved in installation under different military conditions. If the water supply of garrisons, cantonments, and permanent camps is received from that of a civil community having a good natural or purified supply, the water is piped into the camp or post and properly distributed. If the supply is ample, but impure, it is better to treat the whole supply if possible; if not, that used for drinking must be purified. Sand and mechanical filtration are not available, owing to cost and time required for construction. The operation of special filters is expensive, and their output is so small that their employment is possible only for filtering water for drinking purposes. The most satisfactory filters are those of the type used in conjunction with a coagulant. They are not recommended for large permanent camps, because of their small capacity, but they serve the purpose during the installation of some other system.

It is impracticable to purify all the water used in a permanent camp or garrison by heat, ozone, the ultra-violet rays, or by bromine or iodine. The methods employing chlorine as the active purifying agent are the only ones meeting the necessary requirements.

The amount of hypochlorite of lime used is about 1 pound to 100,000 gallons of water. Solutions of 0.5 per cent are usually prepared in concrete tanks, and fed to the raw water by an engineering device at such a rate as to insure a quick and thorough mixture. The chemical should contain 35 per cent of available chlorine.

Water is best purified in the field by the use of hypochlorite of lime. The amount necessary to purify water depends upon the strength of the hypochlorite and the composition of the water, especially in reference to the amount of organic matter it contains. One part per 10,000,000 will reduce the bacteria in water containing little organic matter 99 per cent, but one part per 25,000 is necessary for a similar reduction in sewage. (Ford.) Impure water containing organic matter, when acted upon by hypochlorites, develops unpleasant flavors. This is minimized by filtration through several layers of cloth before the powder is added. For general field service five to fifteen parts per million is recommended.

The easiest, cheapest, and most efficient method of water purification for mobile troops in the field and on active service is the utilization of this method of chemical treatment in the Lyster field sterilizing water bag. The bag is thus described:

"It consists of a canvas bag of specially woven flax, 20 inches in diameter and 28 inches in length, sewn to a flat, galvanized iron ring, hinged so that it folds in one diameter. Spliced at four equidistant points on the ring are two crossed pieces of hemp rope, enabling the bag to be suspended on any convenient support capable of holding the weight of the bag when filled with water, which is about 330 pounds. Five nickel, spring faucets are placed at equal spaces about the bottom edges of the bag. The neck of these faucets is small enough to enter a canteen, which can be filled in ten seconds. The self-closing faucets prevent wastage.

"The purpose of the bag is not for transporting water, but to provide a stationary receptacle in which water can be held long enough to sterilize and then distribute it. The empty bag weighs 7 to 7½ pounds, and folds into a convenient package for carriage in the field.

"After the bag is suspended and filled with water, it is sterilized by the addition of a small amount of hypochlorite of calcium. This is carried in measured doses, sealed in glass tubes. A package of sixty of these tubes weighs 10 ounces, and measures 7½ by 3½ by 4½ inches. Packed in corrugated paper it will stand rough usage.

"The tubes themselves are 3 inches in length by ⅗ of an inch in diameter, and are marked with a file, enabling them to be easily broken in the fingers without fragments. They contain from 14 to 15 grains of calcium hypochlorite. This chemical contains from 30 to 32 per cent of chlorine, which forms in the water hypochlorous acid, and results in sterilizing the water. The process is one of oxidation. In the strength used, waters highly infected are rendered safe. Of course in such strength (1-500,000) grossly polluted water, such as sewage, will not be rendered safe. Water ordinarily used will be entirely safe after being so treated. As the chemical acts more efficiently in clear waters, a filter cloth, to be fastened over the opening of the bag and weighing 1 ounce, is provided, or water may be strained through a blanket. The bag is filled after it is in place. Suspended matter, such as clay, is largely removed, and not left to interfere with the action of the chlorine.

"Comprehensive experiments demonstrate the efficiency of the appliance. The organisms causing typhoid fever, the dysenteries, including amœbic or tropical dysentery, and ciliates are promptly destroyed."

The method of sterilizing water by chlorine gas devised by Colonel C. R. Darnall, M.C., U.S.A., is an improvement over hypochlorites because of its uniform strength and ease and accuracy of dosage. It is not applicable, however, to the needs of troops in the field. In this process the dry chlorine is liquefied by pressure and contained in steel drums holding from 100 to 140 pounds each. The gas passes through a pressure regulator and is admitted to the water pipe; it is readily absorbed by the water, and sterilization is almost instantaneous. It is best applied at or near the pump supplying the camp, so that it may be operated by the operating force of the pumping machinery. The apparatus is simple, admits of various modifications applicable to most conditions of water supply, occupies little space, is almost automatic, and is easily installed. The cost is about 40 cents for each 1,000,000 gallons of water treated.

In temporary camps the conditions are such that no provision can be made for a general water supply, and dependence must be placed on wells and streams. The water must be purified in comparatively small quantities. Small units must be equipped to purify the water for their own use, and the Lyster bag is the best appliance for this purpose. If this is not available, bad or suspicious water should be boiled for twenty minutes. The disadvantages of boiling are the length of time necessary for water to boil and to cool, its consequent flat, insipid taste (unless it be aërated by pouring it repeatedly from one vessel to another, which should always be done), and the quantity of fuel necessary. To overcome these objections apparatus of various kinds have been devised, none of which is now in use in the American Army, though still employed in European armies. They all embody the same principle. Raw water is boiled by petroleum or other fuel and then passed into a compartment separated by a thin diaphragm from that which the raw water occupied before it was heated. A rapid exchange of heat takes place, the raw water being warmed and the purified water cooled. The Forbes sterilizer, of this type, was used successfully in the Philippines. Larger apparatus embodying this principle and mounted on wheels are in use in several European armies. The water undergoes a preliminary filtration, is heated, and carried into the cooling chamber by ebullition and expansion. The wheeled sterilizers are open to the objections of high cost, heavy weight, limited output, and their necessity for fuel, which may not be obtainable. Their use appears to be restricted to the lines of communication or positional warfare. (Ford.)

Water wagons fitted with sterilizing apparatus or batteries of large Berkefeld filters have been used in Europe during the recent conflict. There are practical objections to their use, however. The wagons rattle and draw the fire of the enemy, and so cannot be used to bring the water near the trenches at night. On the retreat from Mons many of the "candles" of the British water wagons were broken or detached, and the units to which they belonged were deprived of all means of water sterilization.

Filtration with coagulation is well adapted to military usage. The Japanese employ the Ishiji filter, which consists of an inverted cone of canvas with two hollow radial arms a short distance from the apex. These are filled with charcoal and sponge disks and are the filters. The heavier impurities settle to the apex of the cone, whence they are discharged through a scour pipe. Precipitation and bactericidal action are caused by a powder of potassium alum, potassium permanganate, and aluminum silicate. After fifteen to twenty minutes a mixture of aluminum silicate and small amounts of tannic and hydrochloric acids are added. The hydrochloric acid facilitates the decomposition of the permanganate, and the tannic acid removes the discoloration of the water. The lateral spouts are then untied and the water allowed to pass through the filter. The result is quite satisfactory with comparatively clean water, but less so with turbid water.

The Darnall siphon filter is quite the best apparatus yet devised for filtering water in the field. It employs precipitation in conjunction with filtration. The precipitant is alum combined with sodium bicarbonate. The apparatus weighs 52 pounds, and consists of a filter tank of galvanized iron, two cans of galvanized iron, a siphon filter and filter cloths of closely woven cotton cloth, and a small hand pump to serve as a siphon primer. The filter cloth is wrapped over the cylindrical metal framework of the siphon, which is placed in the tank filled with raw water to which the precipitant has been added. The water passes through the filtering cloth into the cylinder and is discharged into the water can.

Fresh cloths are sterilized in the can by siphoning boiling water through them. Suspended matters deposit upon the cloth and diminish the flow of water. The filter should then be taken out and brushed; if this does not restore the full flow the cloth must be taken out, washed, and dried. All other parts pack inside the tank, which is transported in a crate. The apparatus has a bacterial efficiency of 98 per cent, and renders ordinary waters reasonably safe, unchanged in temperature and taste, is simple, cheap, easily operated, and furnishes water within an hour after reaching camp. It will deliver 200 gallons of water in four hours.

A simple and satisfactory procedure whereby filtered water may be secured is to dig a pit near the side of a stream, and dip from it the water that seeps through. Such water has been strained by the natural zoöglœa in the stream bed as well as by the intervening soil. In semi-permanent camps this pit may be lined with wattle work, or a barrel, keg, or box, from which both ends have been removed.

Several chemical methods of sterilizing water in small quantities, as in canteens, are effective when intelligently applied by the individual soldier or by small detachments. They are especially useful for officers and officers' messes, and in the cavalry service, whose equipment must be as scant as possible.

Sodium bisulphate, 30 grains to the quart, will purify water so that it can be drunk in about twenty minutes. It can be used in aluminum canteens only, as it forms toxic sulphates with other metals.

Potassium permanganate in the proportion of 1 grain to the quart is slow and somewhat uncertain in the strength used, and imparts an unpleasant taste and color to the water, but has been used successfully in India to purify water supposed to have been infected with *Spirilla choleræ,* which is very susceptible to its action.

Dakin and Dunham have devised an efficient synthetic substance for sterilizing water in the field. It is known as halazone (*p*-sulphon dichloramino benzoic acid) and is put up in convenient tablet form. One part per 300,000 will sterilize ordinarily heavily contaminated drinking water in about thirty minutes, killing such pathogens as *Bacillus typhosus* and *Spirillum choleræ*. Halazone imparts a slight taste to the water, but this does not impair its drinking qualities. It is cheap, easily prepared and has slight if any action on aluminum.

Troops in the trenches are supplied as follows: Water tanks are set up at distances of 1000 yards or more back of the first-line trenches; these are supplied from pipes when such a system is available, otherwise from horse-drawn water carts. When necessary the water in the tanks is sterilized by the hypochlorite process. From the tanks the water is carried in kerosene tins by hand through the communicating trenches and stored in reserve in dugouts back of the support trenches. The soldiers' canteens or water bottles are filled there.

Food. Cases of communicable diseases traceable to infected food are generally found to be caused by infection of the food during or after its preparation by the unclean hands of the men or by flies. The strict supervision of the cooking force as to their personal habits, and constant vigilance in guarding against and eliminating carriers and mild cases of the fecal-borne diseases are prophylactic measures indicated. The protection of the food both before and after cooking is highly essential. Fresh milk, which is the most frequent agent of infection by this mode, is not a conspicuous feature of the soldiers' diet. When used it should be pasteurized, unless its source is unquestionable. The meat supplied to the army is carefully inspected and little is to be feared from animal parasites. The thorough cooking to which it is almost always subjected practically eliminates danger from this source.

When cholera and dysentery threaten a command and when serving in the Orient, where the fecal-borne diseases and animal parasites are transmitted to man by green vegetables from beds fertilized by human manure or watered with sewage, the consumption of these vegetables must be avoided or they must be sterilized before they are eaten.

Air. Sanitarians are now firmly convinced that the aërial transmission of disease is largely confined to "droplet" infection, a phase of contact infection.

The ventilation of barracks is planned and operated according to the accepted principles of hygiene, and presents nothing peculiar.

The ventilation of tents in cold weather is apt to be ignored. There is a tendency to close all air holes. During the mobilization on the Mexican border, when Sibley stoves were installed, a metal hood with a hole through the side to accommodate the stove pipe was substituted for the canvas hood on all pyramidal tents. This hood was raised 4 inches above the canvas and gave protection from the rain and at the same time ensured a certain amount of ventilation.

Fomites. This means of disease transmission among soldiers has little more than academic interest, as the former faith in fomites infection, e.g., the transmission of long-persistent germs by clothing and bedding, is now mostly discredited and replaced by belief in contact, direct or indirect, with comparatively fresh infectious material. The practice of medical asepsis in all cases of communicable diseases, systematic and scientific efforts to detect mild cases and carriers and a decent regard for the rules of personal hygiene tend to prevent the formation of fomites, and thus minimize such danger as exists from that mode of infection.

Chapter XI

NAVAL SANITATION

Manifestly an attempt to embody in a work of this kind a thorough discussion of the principles of naval hygiene would be a futile waste of time, therefore this section will be limited to a brief description of the available measures now in use to prevent and control the communicable diseases in naval life, afloat and ashore. More or less familiarity on the part of the reader with naval and maritime conditions is presupposed.

Contact Infection. The conditions under which the naval recruit lives at the camps and training stations are similar to those prevailing at military camps and barracks, and the same principles that guide the military sanitarian in the prevention of communicable diseases must be followed by his naval confrère.

The following is the substance of the instructions to medical officers of the Navy, for the prevention and control of communicable diseases, contained in a circular letter from the Bureau of Medicine and Surgery under date of September 17, 1917:

The danger of infection by close contact, especially "droplet infection" in the acts of talking, laughing, coughing, sneezing, spitting, and snoring, must be avoided by reducing to a minimum close personal contact in the housing of large bodies of men in camps or barracks, even though the men are apparently healthy. To this end it is of paramount importance that all recruits in detention in camps and training stations be segregated for a period of twenty-one days before they are permitted to mingle with the main body.

If disease is present, or if recruits are being received from districts where communicable diseases are prevalent, emphasis must be placed upon the great importance of the early detection of cases, prompt isolation of patients, separation of the contacts of each type of disease, in segregation for observation, and detention of all carriers in connection with such diseases as diphtheria, cerebrospinal fever, malaria, and typhoid fever.

Apart from such considerations as sufficient floor area per individual and proper ventilation, the number of men housed in any one building or room should be small. When large buildings have been occupied, it has been necessary to abandon them after the advent of communicable diseases and to divide the men into smaller units. When large dormitories are fully occupied, there must always be apprehension of danger.

In sleeping quarters, beds or cots should be placed or hammocks swung with not less than 5 feet between center lines. This is important. Overcrowding means close contact, and close contact means the ready transference of nose and throat secretions. Therefore individuals should always be separated from each other as far as practicable. The above figure is reasonable, as it will give an aisle of 2½ feet between cots or hammocks and approximately 5 feet of space separating the heads of occupants. In the interest of disease prevention this distance might well be increased, but it should not be decreased without the strictest necessity. Where the floor area is limited and cannot be increased, or the number of occupants reduced, the arrangement of cots or hammocks should be such as will secure the maximum separation between the faces of the men occupying them.

In the care and treatment of pneumonia, acute tonsillitis, and catarrhal infections of the respiratory tract, it should be borne in mind that these are all communicable diseases which may be disseminated by droplet infection, that secretions from the nose and throat are a source of danger to others as long as they remain moist, and that other patients should be protected from infection by their removal to a safe distance or by isolation of patients ill with communicable diseases of the respiratory tract. In suitable cases screens may be used to limit the projection of infective secretions.

Medical officers are directed to exert themselves to the utmost for the prevention and early treatment of venereal diseases by carrying out conscientiously the authorized medical prophylactic treatment and by the full use of lectures, personal talks, and circulars. In such discourses the medical officer should not only explain the dangers of venereal diseases, but should emphasize the importance of personal cleanliness, especially the importance of washing the hands after visiting the toilet and before eating.

At times the ship's barber shop has been a focus of infection, especially for parasitic skin diseases. This danger is eliminated by enforcing the modern sanitary precautions in regard to the sterilization of instruments, the use of clean towels for each customer, the use of clean paper on the head rest of the chair, the removal of cut hair, and the personal cleanliness and health of the barber himself.

The subject of the ship's drainage, bathing and washing facilities, and water-closets and urinals have important bearings on contact infection.

The drainage system of a ship follows the principles of the separate system. The water of the flushing system, after passage through the water-closets and urinals, wash water, refuse from the ship's kitchens or galleys, ashes from the furnaces, sea water coming on board, and rain water, are discharged overboard in the most direct manner by waterways or scuppers or both. The refuse water, oil, etc., from the engine and boiler rooms, similar fluids from the magazines and storerooms, the wash water, sea water, and drain water from the lower decks gravitate to the most dependent parts of the ship and are collected in a space technically known as the bilge room. This vile mixture is known as bilge water, and is pumped overboard by suction pumps which terminate within a few inches of the bottom of the ship. Their open mouths are directed downward and are protected by wire-gauze baskets to prevent the entrance of solid matters. The drainage system of a wooden ship or an iron merchant ship is comparatively simple, but that of a modern man-of-war is very complicated. The drains are divided into main, auxiliary, and secondary, according to size. The main drain of a large war ship is used only to pump out large quantities of water should the ship's bottom be punctured; the auxiliary drains are employed when the accumulated bilge water is removed at regular intervals; the secondary drains draw off the smaller local accumulations of bilge water.

The drainage and pumping system below the berth deck of a battleship or cruiser is divided into emergency, surface, and double-bottom drainage. Each part is composed of separate piping, but is connected with the others by valves, thus enabling the system to be operated as a unit, or each part may be worked independently.

The main or emergency drain is a pipe extending from the after part of the forward fireroom to the after part of the after engine room. It generally runs on one side of the ship, throughout the length of the boiler compartments. Just aft of the forward bulkhead of the engine space it branches, and a branch is led into each engine room and connected to the main centrifugal pump in each room. The main pipe varies in size from 5½ inches to 15½ inches, according to the size and type of the ship. Where water-tight bulkheads are pierced by the drain, water-tight flanges are utilized. The main machinery compartments are connected with the main emergency drain by branches, which are led through the center-line bulkhead and fitted with valves at the end. Full-diameter suction valves in the main drain are located in each compartment through which it passes. These are operated at the valve and also by rods from the deck above. All steam pumps which have any connection with drainage have suction connection with the main drain. By this means one or all pumps may be utilized in clearing the ship of water. The main drain is utilized only when the water in a compartment is rising above the floor plates and is beyond control by the other parts of the drainage system. Emergencies of this kind are created by the ship striking a rock and piercing the double bottom, or by being struck by a torpedo.

The secondary drain usually traverses the vessel on the side opposite to the main drain, and extends from the forward end of the forward boiler room to the after end of the after engine room. It is connected to a manifold (a series of valves embodied in a chest) at each end, and has branches leading to each bilge well in every compartment of the machinery space. Bilge wells are rectangular depressions about 10 by 18 by 6 inches, constructed in the inner bottom plating of each water-tight compartment. The suction ends of the suction pipes are placed in the bilge wells. By this means each compartment may be pumped dry. This is known as surface drainage, and disposes of all water that collects on top of the inner bottom in engine and boiler rooms, in storerooms, or other spaces except double bottoms.

Every steam pump connected with the drainage system, except the main centrifugal circulating pumps, has a suction connection with the secondary drain. The system is so planned that by manipulation of valves, any compartment may be pumped out by any pump or by all pumps, as necessity may indicate. The pumping of the several compartments, forward and aft, may be controlled from within the machinery space by means of manifolds, from which the branch pipes extend to the compartments. The pipes and pumps are protected from clogging with solid materials by Macomb strainers on the suction ends within the machinery space and by perforated box strainers on the suction ends outside of the machinery space.

An independent suction leads from each pump to the bilge well of its own compartments by means of which each compartment may be kept dry without relying upon the secondary drain.

The crank pit is pumped by a small pump on the main shaft of the engine. It may also be drained by the secondary drain and an independent suction. The double bottoms under the machinery space are either flooded or pumped through the double-bottom flooding or pumping main. A branch controlled by a valve leads from this pipe to each watertight compartment of the double bottom. The double bottoms forward and aft of the machinery space have suction connections with the secondary drain, and their pumping is controlled through the manifolds. They have no flooding connections.

When water collects under the floor ceilings of the coal bunkers, it is removed by means of those led through the bunker doors. The magazines, exclusive of the handling rooms, are pumped out after flooding by means of hose led through a cap in the top of the magazine.

On modern steel ships sea water is no longer the chief constituent of bilge water, as salt water now gets into the bilge room only through the shaft alley. With ordinary care the bilge room of these ships can be kept dry. Frequently the spaces between the timbers are filled with cement in such a manner as to guide the flow of bilge water from one partition to another through holes in the timbers or frames known as limber holes. This prevents accumulation in any one partition.

It has been demonstrated that bilge water seldom if ever contains pathogenic bacteria, and that the latter will only survive in it a few hours. Nevertheless it is a source of contamination of the ship's atmosphere and its accumulation is unjustifiable.

Surface drains or open channels called "water ways," as found on ships, are constructed of metal and extend around an open deck to receive the rainfall or the water used in washing down. They discharge into scuppers which are closed drains that carry overboard the drainage of whatever character from all the decks and fixtures above the berth deck. They are made of composition, and discharge near the water line or above cofferdams, where they are provided with extensive lips to throw the water clear of the ship's side. They are placed more or less vertically wherever a closed drain is required. The flow is entirely by gravity and is very rapid. All open decks, bridges, hammock berthing on weather decks, military tops, searchlight platforms, boat cranes, tops of chart houses, and similar surfaces are drained by scuppers. The floors of such spaces as washrooms, shower baths, crew's heads or toilets, and galleys have complete drains discharging into a main scupper at an angle not exceeding 20°. Scuppers are utilized to carry overboard the discharges from water-closets, urinals, and crew's head. This arrangement possesses the sanitary advantage of short piping and rapid flow, and in water-closets and urinals of unlimited supply of salt water for flushing. Nevertheless, the plumbing should be entirely exposed and even more carefully constructed, ventilated, and safeguarded against return than in the cases of houses discharging into municipal sewers. The great concentration of men on a ship makes even short pipes liable to slowly forming accumulations of filth; the flushing water, by its hardness, lack of solvent power, and the roughening of pipes, facilitates much clogging by slow deposits. The utilization of the hot-water discharge of the distiller, because of its greater cleansing power, has been attempted, but has been abandoned on more recent ships on account of the personal discomfort involved.

A ship at sea, especially in rough weather, is constantly changing its water line; this tends to the backing of water up drains and the forcing of their contained air into the interior of the ship. Sea water itself may be thus forced up into a sanitary fixture draining by gravity, if too close to the water line. To limit this action the discharge openings of scuppers are protected by flap valves that automatically close when the end of the scupper is buried in the sea. Drains are provided with air vents and are fitted with strainers, traps, and cleaning plugs. Floor drains are often of the stop-valve type. The drain pipes of ships are or should be fitted with a steam connection for blowing out. (Gatewood.)

The shower bath is very well adapted for use aboard ship both from sanitary and utilitarian standpoints. The bathtub should be condemned. The shower bath permits more men to bathe, as it requires less time, it occupies less room, and, therefore, permits a greater number of fixtures in an equal space; the soiled water is immediately removed from the body, thus diminishing or removing the danger of disseminating the communicable diseases; less water is required than in bathtubs. The supply of fresh water is so limited that salt water is used in the showers. Officers' baths have both salt and fresh-water connections.

The flooring in shower-bath inclosures should be tiling laid in cement, sloped to prevent standing water, with a drain for each group of not more than four showers. Tiled or stone and cement flooring should be used in crew's heads, all water-closet spaces, bathrooms, washrooms, galleys, bakeries, laundries, operating rooms, and at the scuttle-butts or drinking fountains.

The lavatories for the firemen and crew of large naval vessels are supplied with cast-iron, roll-rim, porcelain-lined, tip-up basins. These are arranged on trunnions over a trough and tip in the direction of the trough. No more than six basins are contained in any one trough. The troughs are fitted with brass strainers and brass S or half S traps in the drain pipe. This plan is more sanitary in crew's quarters than stationary basins with separate piping. The lavatories of the deck force are provided with salt water only, but those for firemen on large recent ships have both fresh- and salt-water connections.

Lavatories and shower baths near the water line drain into the cylinder of a sewage discharger which is a form of self-sterilizing pump operated by steam, that automatically discharges the sewage overboard, 5 gallons at a time. This has taken the place of the so-called sanitary tank into which water from the lavatories and showers was formerly drained and then pumped out at irregular intervals by pumps of varying types. Sediment was apt to accumulate in them and become offensive. Other fixtures on upper decks discharge directly overboard by gravity through scuppers.

There should be a minimum of one shower bath for every twenty men and one lavatory basin for each eight men, which can only be approximated on large ships.

Lavatories for chief petty officers, mess attendants, and for the dispensary are more roomy than those for the crew. They are fitted with all-porcelain, vitreous-glazed, roll-rimmed basins. Each basin has a soap cup molded in the right-hand corner and combined standing and waste overflow at the left-hand outside of the basin. The dispensary contains a single basin, but larger than the others.

The lavatories for officers, sick-bay, sick-bay bath, and operating room are similar to standard types on shore.

Stationary basins in staterooms are not to be commended. If the connection is with a fixed discharge pipe there is chance of air contamination in the small air space of staterooms. These are now provided with wash bowls mounted in rings, water pitchers, and slop jars, the latter placed in rings just below the bowls. The bowl is emptied by pulling out a plug in the bottom without removal from its supporting ring.

The ring for the bowl is hinged, allowing it to be secured out of the way against the bulkhead.

Crew's lavatories should not be placed in heads, but in separate spaces. Heads cannot always be kept clean, and washrooms are frequently wet. This diminishes the tendency to bathe, and facilitates the dissemination of infectious material through the ship.

The water-closet of the crew on most ships, particularly the older ones, is the trough type. It is constructed of heavy tinned copper. The bottom is inclined to the drain opening, which is about in the middle. It has salt-water connections for end flushes, also 1-inch diameter perforated flush pipes fitted high at the back and in front and extending the full length of the trough. The flushing is continuous, and is controlled by a key valve. The discharge is by a special scupper, which should not connect with a floor drain or the discharge from other fixtures. The same applies to the special scuppers of all sinks, urinals, and water closets.

Each seat is within a galvanized steel stall. They should be of seasoned ash, of sufficient thickness to stand very rough usage, and specially treated with paraffine to limit their power of absorption and to facilitate cleaning. They should be frequently examined and kept in constant repair.

The principal objection to the trough closet is the danger of dissemination of the fecal-borne diseases by splashing which is accentuated in a shallow trough by the continuous flushing that is apt at times to be excessive.

The tendency now is to install on new ships all-porcelain, vitreous-glazed water-closets for the crew. They are flushed from the rim by a brass slow-closing flush valve, with a cast-iron weighted handle with a support. These closets are easier to keep clean, but they are frequently used as urinals, and the seat and deck become contaminated with urine that may be infected.

The trough urinal, while not perfect, is the most suitable for the crew. The type in general use is a rolled-rim, lipped trough made of porcelain-lined cast iron. It is flushed by a perforated ¾-inch copper wash-down pipe fitted across the back and a 1-inch end flush at the end opposite the drain opening. Both are controlled by key valves. The drain opening or waste outlet is fitted with a strainer and a brass S or half S trap.

Most of the water-closets for officers, including those for chief petty officers, are the single-valve type when situated above the berth deck and pump closets when on that deck. The siphon closet has been installed on some new ships in officers' quarters above the gun deck. All water-closets, except the pump closet, discharge by gravity. The principal use of the pump closet has been on ships when the situation appropriate for a closet near or below the water line did not permit the installation of a gravity closet. The bowls of all closets are all-porcelain, vitreous-glazed and rim flushing.

The pump closet is complicated, inconvenient, and insanitary. The bowl is flushed by a connection from the flushing system controlled by a foot tread, and the contents discharged overboard by a hand pump. The use of sewage dischargers such as the Hermes now permits the installation of a closet of approved type in any location where the discharge pipe of the closet can be given sufficient fall on the way to the sewage discharger. In utilizing the latter in connection with water-closets some difficulty may be experienced in obtaining a sufficiently short or vertical lead for the discharge pipe of a closet placed well forward or well aft. This is due to the fact that, while the sewage discharger is always much below the water line, it is located in the engine room, generally about amidship.

The valve closet, while a sanitary anachronism on shore, has been retained aboard ship on account of the valve being a protection to the water seal during the plunging of the ship in heavy seas.

The tendency now in building new naval ships is to locate all water-closets and wash-rooms above the berth deck, to utilize gravity to discharge the waste, and to replace the sanitary tank with the sewage discharger.

Carriers. The danger of infection by carriers to which naval men are subjected is indeed great, as life aboard ship necessarily involves much close personal contact. Diligent and systematic search should be made for carriers among the recruits at the training stations and camps. Men coming from infected districts should be examined for malaria and for hookworm, and the necessary treatment administered to the carriers who are detected. Malaria carriers must be protected from mosquitoes.

When a case of typhoid fever, cholera, cerebrospinal meningitis, or diphtheria whose origin cannot be clearly traced, appears aboard ship or in a training station or camp, a systematic search for carriers with such bacteriological and serological means as are available should be instituted, especially among the cooks, messmen, and others handling food. When found, carriers must be placed in at least constructive or sanitary isolation until they are free from the infection or removed from the ship. They and those with whom they necessarily come in contact must practice strict personal hygiene, particularly as to cleanliness of the hands and, in infectious diseases of the nose and throat, the avoidance of the possibility of droplet infection.

No carriers of the fecal-borne diseases or diseases spread by oral and nasal secretions should be allowed on duty in the galley, bakery, butcher shop, or laundry, or should be allowed to clean the fresh-water tanks.

Infection by carriers is closely interwoven with the subject of contact infection, and the more deeply the men are impressed with the importance of personal cleanliness and hygiene the less will be the danger from carriers.

Insects and Other Vermin. A biologically unclean ship is an ideal place for the spread of insect-borne diseases. The frequent occurrence of typhus in navies and in the merchant marine gave it one of its many names, "ship fever." In the days when "yellow jack" flourished in the West Indies and on the West Coast of Africa the crew of many a ship was decimated by that dread disease. Plague spreads along maritime commercial routes, as the rat is a great sea traveler. To this day the Navy personnel suffers from malaria and dengue in infected tropical and semi-tropical ports.

Mosquitoes. In shore stations and navy yards protection against mosquito-borne diseases is a part of general sanitation. Whenever possible, ships should lie well out from shore in mosquito infested ports or navy yards. If a ship is anchored a mile from shore she is apt to remain free from mosquitoes, except such as come on the market boats or bumboats. The destroyers at Cavité remained free from mosquitoes at a much shorter distance. If it is necessary for the ship to lie alongside the dock or to go into dry dock, the doors, port holes, light ports, and other openings should be screened with screens made of copper wire cloth, eighteen strands to the inch. This has been proven to be practicable and efficient. When moored or anchored close to the shore in an infested port, or when cruising on a river where mosquitoes are present, if screens are not available the use of mosquito nets is imperative. When in such localities it is important that no vessels of water remain uncovered, and that no pools of water be allowed to accumulate in the boats or elsewhere about the ship. If a mosquito-borne disease occur, search should be made for such vessels or accumulations of water and for hibernating mosquitoes. It may be necessary to clear the ship of mosquitoes with insecticides. If mosquitoes are present, all patients ill with mosquito-borne diseases must be kept under mosquito nets during the period of infectivity.

Only military, naval, or diplomatic exigencies justify the sending of a ship or squadron to a malarious port or into a yellow-fever-infected harbor. Such service is fraught with grave danger, notwithstanding our recent advances in sanitation. It is, nevertheless, one of the risks that must from time to time be undergone by the naval force afloat.

Flies. When alongside docks or in dry docks in warm weather, flies frequently come aboard ship in large numbers; they are also brought on board on the clothing of persons and on marketing and fresh provisions. The fresh-vegetable lockers are a common breeding place of flies aboard ship. They breed in decomposing vegetables, especially onions, and unless the source of supply of flies is recognized the ship rapidly may become infested with them. (Pryor.) In ports where garbage is not thrown overboard, but is sent away from the ship in lighters, flies frequently accompany the lighters from shore, and when cholera or typhoid fever are prevalent are a real danger.

When flies are present the food supplies must be kept covered or screened, and vegetable crates and lockers should be covered with tarpaulin. During warm weather and in the tropics the vegetables should be sorted weekly to prevent fly breeding and to remove rotten vegetables. Garbage lighters returning to ships should be hosed down to eliminate the flies. The insects should be driven off the market boats as the boats approach the ship.

Decomposing animal and vegetable matter should not be allowed on board ship. When garbage is not thrown overboard or removed in lighters it should be incinerated. When anchored at a distance from the shore, or when under way, flies may be driven from many compartments, such as the galley, by permitting the escape of free steam, which is offensive to them.

Lice. The body louse is an infrequent visitor aboard ships of the Navy. The natural instincts of cleanliness and decency of the men, the liberal use of soap, the frequent changing of clothes—in fact, the general cleanliness possible and enforced—prevent the infestation of this unwelcome guest. The eradication of this insect is discussed in the chapters on "General Prophylaxis" and "Military Sanitation."

The crab louse is more frequently seen, but the daily scrubbing and frequent disinfection of the crews' water-closets prevent its dissemination.

Fleas. The presence and eradication of fleas and their relation to the transmission of disease aboard ship are intimately associated with the presence or absence of rats. The general cleanliness of men-of-war prevents their breeding in cracks, crevices, etc., which cannot be said of tramp steamers and sailing vessels. Both pyrethrum powder and coal oil are effective against fleas. If necessary the infested part of the ship may be fumigated with sulphur dioxide or hydrocyanic acid gas.

Bedbugs. It is practically impossible to prevent the occasional introduction of bedbugs aboard ships of the Navy. They come aboard in laundered clothes, in the baggage of the men, and upon the clothes of those returning from liberty spent in infested houses, and also by other known and unknown means. When sheathing, upholstery, etc., become infested, their extermination by any means but fumigation with a gaseous insecticide is impracticable. They are nearly always present in the crews' quarters of merchant ships.

Frequent inspections must be made to guard against these pests. If the infestation is serious enough to call for a gaseous insecticide, sulphur or hydrocyanic acid should be used. If the bugs are few in number, pyrethrum powder may be tried, but is not reliable. Coal oil and benzene injected or sprayed into cracks are effective, and strong bichloride of mercury solution is of value. Pryor states that the gasoline torch and the steam hose are useful aboard ship.

Cockroaches. These vermin are enemies of the bedbug, but that does not justify their existence aboard ship, where they multiply rapidly, especially in warm climates. Sodium fluoride dusted into the runways or hiding places of the insects is the most effective poison, but is not trustworthy in the presence of moisture. Phosphorous paste and traps are successful in destroying roaches.

Aboard ship the jet from the steam hose will often prove an excellent means of exterminating cockroaches in cracks where mechanical cleaning appears impracticable. (Pryor.)

It may be necessary to fumigate the infested compartments with sulphur dioxide or hydrocyanic acid gas.

Rats. Rats are fond of ship life, and find happy homes on dirty ships of the merchant marine, especially grain-carrying vessels, and are not only a menace to passengers and crew, but by them plague has been carried to all parts of the world. When discovered aboard ship their eradication by systematic trapping should be undertaken; the food supply must be protected from their depredations; the use of rat guards on mooring lines while tied up at docks should always be insisted upon in ports where there is the slightest danger of plague; the lines should be tarred; the gangplank should be triced up at night, and during the day a man should be stationed at it to prevent rats reaching the ship by this route. The animals are good swimmers, and have been known to swim three-quarters of a mile and come aboard ship by way of the anchor chain and an unprotected hawse-pipe.

The de-ratization of ships by fumigation is described under "Disinfection and Fumigation of Ships."

Water. The danger to the naval personnel from water-borne diseases is practically confined to officers and men on shore duty, especially in the tropics and the Far East, or is incurred while ships are in port or in navy yards for repairs. Their prevention under those circumstances is a part of general hygiene. In recent years few if any water-borne diseases have been correctly associated with the question of the purity of any ship's water supply. However, circumstances may arise on any ship, naval or merchant, under which the water tanks must be filled from questionable sources ashore, and naval sanitarians cannot disregard this source of danger. Theoretically, no water should be taken on board unless its source is definitely known. Its quality should be such that the danger of introducing water-borne diseases is precluded. In former times much dysentery was due to infected water from Oriental and tropical ports, but since the introduction of distilled water the naval force afloat has been relatively free from that disease.

Sailing vessels and small steamers not provided with distilling apparatus must carry sufficient water for use between ports. In the merchant marine this is generally reckoned at 3 quarts daily per man with an additional amount for cooking. It is stored in metallic tanks or wooden casks. Tanks are generally made of galvanized iron, and are sometimes lined with cement. They should be placed in positions easy of access for cleansing and inspection. Storage in casks is unsatisfactory, as the water deteriorates rapidly, due to the action of the water in extracting matters from the wood and to the decomposition of these matters. When casks are made of hard wood and thoroughly charred inside there is less extraction and decay of soluble matters. Ships provided with distilling apparatus do not need to provide for the storage of large quantities of water. Distilled water is superior to water stored for any considerable time, however good the latter may have been originally.

Naval vessels and nearly all the larger ships of the merchant marine are equipped with distillers for the production of drinking water from sea water. Distillation is the conversion of a liquid into a vapor by heat, and its recondensation into the original form by cold. As this process is carried out on ships, the apparatus designed for the first stage is known as the *evaporator*, and that for the second stage the *distiller*, sometimes called the *condenser*. The evaporator is a horizontally placed, cylindrical steel shell, the lower half containing tinned copper or brass tubes with soldered joints running lengthwise and fixed at either end in a plate, which allows the entire battery of tubes to be removed *en bloc*. Steam, generally at a pressure not exceeding 40 pounds, is conducted from the main boilers into the tubes, which are surrounded by the sea water to be distilled, which does not quite reach the highest level. The pressure within the cylinder is about 10 pounds.

The distiller or condenser is a brass or iron cylinder, placed vertically and equipped with straight tubes for circulating cooling sea water, which enters at the bottom and discharges at the top.

The heat of the steam in the evaporator tubes causes the evaporation of the sea water which surrounds them; this vapor passes through a steam pipe to the distiller, entering at the top; here, by contact with the tubes in which is circulating the cool sea water, the steam is condensed into sweet, distilled water.

Large distilling plants are arranged somewhat differently from the foregoing, the process being divided into two or three stages, and the working efficiency of the plant correspondingly increased. According to this plan steam from the ship's boilers is utilized to evaporate the water in the first or high-pressure set of evaporators; this steam is used to evaporate sea water in the second or low-pressure set of evaporators, and this steam is finally used in heating and evaporating the sea water in the third set, the vapor from the last being condensed in a distiller. When two evaporators are thus used they are said to be working in double effect; when three sets are employed they are being operated in triple effect.

Certain precautions are necessary in operating a distilling plant: (1) Dirty harbor water should not be used, as the distillate will not be free from taste and odor, on account of volatile products in evaporation. (2) When distilling water for drinking purposes, the evaporators should never be pushed to their full capacity; this reduces priming, e. g., the carrying of sea water over with the distillate. When at sea and rolling heavily, the apparatus should be operated at its lowest capacity for the same reason. (3) The water level in the evaporators must be kept low. (4) The pressure of cooling water in the tubes of the distiller is limited to 30 pounds, in order to minimize the danger of the salt sea water leaking into the distiller and contaminating the fresh distillate. (5) Daily

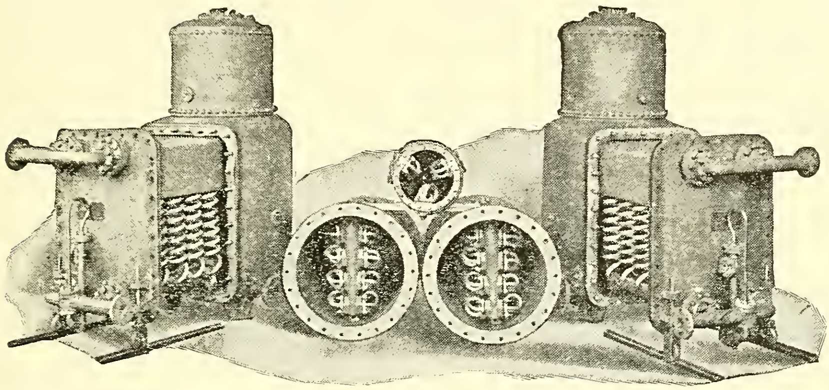


FIG. 26.—NAVAL WATER DISTILLING PLANT. (*Courtesy Griscom-Russell Co.*)

tests of the whole plant should be made as to tightness of joints. (6) The distillate should be tested with nitrate of silver for chlorides during every watch.

"Sudden increase in saline content of distillate should never be ignored. The cause is frequently a leaky tube. If the sea water be taken well off shore, e.g., 100 miles, such a leak means little except that the drinking water shows more salt than usual. This is in such small quantity that it is not apt to do more than render the water a little less palatable. Such a leak, occurring when the ship is lying in a sewage-polluted harbor, is a much more serious matter, as the health of the personnel may be menaced." (Pryor.)

The general disposition in the Navy is to supply as much fresh water as is practicable for drinking, cooking, and usually for bath and laundry purposes, and to insist upon no avoidable waste. The Navy Regulations require commanding officers not to limit, unless absolutely necessary, the daily allowance of fresh water to less than 1 gallon per man for all purposes, and that he shall also, when practicable, issue fresh water to be used for washing the soiled clothes of the crew. Fresh water is taken aboard from hydrants at docks or from water boats. Distilled water is made from sea water or from fresh water whose purity is questionable. In time of war, when coal consumption must be considered, distillation may not be practiced. If the impure fresh water cannot be distilled, it should be chlorinated. This should be done as soon as the water is taken aboard, and repeated just before the water is used for drinking, which would prevent the result of possible bacterial infection by an enemy. The second chlorination probably would be unnecessary if the drinking-water tanks are under proper bacteriological supervision. (Pryor.)

When water is distilled or is received for storage on board ship, it enters the tanks through pipes from pumps and leaves the tanks through discharge pipes for distribution to smaller gravity tanks, which give pressure to the water as it goes to the fixtures. Distilled water is, therefore, not exposed to infection from the time it leaves the distillers until it reaches the fixtures.

When fresh-water tanks are cleaned they should be entered through manholes on the sides rather than on the tops of the tanks, thus preventing the entrance of dust which may have collected on the tops. Clean rubber boots and fresh, clean clothing should be worn by all men entering the tanks for work. The tanks should be thoroughly scrubbed with soap and water, rinsed with disinfecting solution if necessary, then with fresh water, and finally steamed thoroughly with the steam hose before permitting the entrance of freshly distilled water.

The sanitary drinking fountain, involving the principle of the "bubbling spring" or fountain for each faucet of the ship's scuttle, butt, or tank, for fresh drinking water tends to decrease infections spread by oral secretions. The immersion of drinking cups in formaldehyde is not as efficacious as the sanitary fountain.

The pipes of the fresh-water system should have steam connections for sterilization purposes.

Salt water is piped over ships for flushing closets, baths, in pantries, fire mains, etc. In harbors there is an element of danger in this, as there is in washing the decks with harbor water. Food on mess tables may be infected from surfaces moist with polluted water. Careless mess attendants or stewards may rinse dishes in harbor water from a salt-water pantry faucet.

A ship's plumbing should not be complicated. There should be no chance of a mixture of distilled water and harbor water. When there are connections at bathtubs between the fresh water and the flushing system, so that water from both systems can reach the tub through a faucet in common, as is the case with cold and hot water in bath tubs on shore, there is danger at times of the backing of water from salt-water pipes into fresh-water pipes. This is due to the fact that on ships the pressure in the flushing system is maintained by pumps and is much greater than in the fresh-water pipes, which are fed by gravity from the fresh-water tanks.

A danger that must be guarded against is swimming by the crew in contaminated harbor water that is frequently a carrier of the sewage of large populations. Equally great is the danger of supplying the ship's shower baths with harbor water, as a certain amount of water gains access to the mouth, either directly or in drying the lips.

Food. Fresh milk, which more frequently transmits communicable diseases than any other food, has only a limited place in the Navy ration, evaporated milk being largely used. In times past a number of epidemics of typhoid fever were considered due to infected milk. When fresh milk is used in the general mess it should be boiled, while officers' messes should use only certified or inspected milk. The protection of the naval personnel by typhoid inoculation is no reason for running unnecessary risks. In the tropics or in Oriental countries fresh milk should never be used unsterilized.

The careful inspection, cooking, and serving of food in the Navy has largely eliminated this source of disease transmission. When stationed or cruising in the Orient, where human manure is used in the gardens, fresh vegetables are dangerous when uncooked.

Bumboats—small boats which come out to ships and receive permission to sell fruit, eggs, milk, candy, soft drinks, cakes, etc.—are not now allowed, as the need for them is not felt since the establishment of the canteen. However, small dealers selling filthy wares sometimes gain admission to navy yards, and an elastic construction of the prohibitory regulation often permits the purchase of fresh eggs and fruit from bumboats. These boats are inspected by the medical officers of naval ships when they come alongside at the port gangway. The officer should carefully examine their general condition and the general arrangements of their contents from the point of view of contamination by dirty water in the boat or from the harbor. The condition of cleanliness of the bumboatman himself as well as his wares should be borne in mind. He must be impressed with the fact that he cannot serve the ship unless he furnishes clean goods. No food unprotected from harbor water is safe. If the bumboatman has not the necessary baskets or boxes, it may be well to supply him with boxes or barrels from the ship. Bumboats should not be allowed to visit the ship in cholera-infected ports.

Cooks, stewards, and messmen in the Navy and in the merchant marine have been agents for the dissemination of communicable diseases, and coming into contact, as they do, with large numbers of men and the food for these men, they must be regarded as potential sources of infection. Strict cleanliness of habits and person must be enforced. When a search for carriers is indicated, the messmen and commissary branches in the Navy and the steward's force on merchant ships must be most carefully scrutinized.

Air. When on deck the sailor breathes sea air, the purest air known; when below decks, especially on old types of ships, he may breathe the foulest known. Contributing causes of this latter condition are an excess of aqueous vapor from respiration and from water used in washing down the decks or shipped over the sides when under way, an excess of carbon dioxide from respiration, combustion of illuminants, and decomposition of organic matters, effluvia from bilge water and from sea stores such as oil, tar, and paint, and on merchant ships from components of the cargo. Happily on modern ships, especially men-of-war, these conditions have been greatly improved by mechanical ventilation, better construction of ships, and the use of the electric light. The danger from long-continued exposure in compartments in which tuberculous sputum or other infectious discharges have dried on the decks or other surfaces does not exist in the Navy nor on cleanly merchant ships.

The constant breathing of impure air below lowers the vitality of seafaring men and increases their susceptibility to communicable diseases, particularly tuberculosis. In former times there was a high morbidity among sailors from respiratory diseases superinduced by the great atmospheric humidity caused by the excessive use of water in washing down the decks, especially in cold weather.

The principles of the ventilation of ships are the same as those of the ventilation of buildings, but their application is more difficult and the problem more complex, due to peculiarities of construction and to external conditions.

Under favorable weather conditions natural ventilation may be effected in small vessels and materially assisted in large ones through hatchways, portholes, and other openings and by means of windsails (canvas tubes or funnels with a side opening at the top, stayed to face the wind or the ship's course), fixed ventilating tubes with movable cowls acting in a similar manner, hollow masts, and other devices.

Deckhouses and top-gallant forecastles are efficiently ventilated through portholes. Lower forecastles are frequently ventilated only through hatchways, and these are apt to be closed in bad weather. Ventilators, capped with cowls, are sometimes utilized, but the draft often causes the sailors to close them. Between-deck spaces and holds are ventilated through hatchways, fixed tubes, windsails, hollow masts acting as ventilating flues, or by funnel casings which act like jacketed stoves.

Large vessels, and many small ones, such as destroyers, can be ventilated only by the mechanical propulsion and extraction of air. The efficiency of the ventilating plant depends upon the intelligence used in planning the system of ducts and valves. Two methods of artificial ventilation are in use—the plenum or supply method, and the vacuum or exhaust method In the former the air is driven through the ducts or pipes by fans or blowers driven by electric motors, in the latter it is sucked through by the fans. Either one may be used alone, but more frequently both are utilized on the same ship. As it is more important to provide an abundant supply of fresh air in the ventilating of ships than it is to get rid of foul air, the plenum system is, for most purposes, the better. This method puts the compartment supplied under slight pressure and prevents leakage of air from surrounding compartments; it accelerates the escape of foul air through natural outlets, and the source and velocity of the air supply are under control, a steady current of fresh air to all compartments being thus assured. By tending to produce uniform conditions of temperature and pressure it prevents untoward currents and countercurrents between the different compartments.

The vacuum or exhaust method causes a current of air in a compartment by creating a partial vacuum within it. The air will flow into the compartment through every available channel from whatever spaces have a greater pressure than the compartment ventilated. Atmospheric conditions in such a compartment are not under control, but are influenced by conditions in the surrounding compartments. It is especially useful in ventilating water-closets.

Fomites. The decent regard for cleanliness enforced in the Navy minimizes, if it does not absolutely prevent, infection in this manner. It is doubtful if fomites, as such, are often brought aboard ship. As on shore, it is persons, sick or well, and not things, from which we have most to fear in the dissemination of communicable diseases. When cases of communicable diseases appear, precautions must be taken that no fomites are created. This is accomplished by *medical asepsis,* the careful bedside disinfection of clothing, bedding, utensils, patient, nurse, and physician. If this is carefully and successfully practiced, and if carriers are watched for and eliminated, there will be no fomites.

Chapter XII

RAILWAY SANITATION

During the past twenty years the impression has prevailed that railway cars have some peculiar relation to disease in general and to communicable diseases in particular—an impression which is erroneous, as cars are only mobile habitations. It is true that hygienic considerations have been considered but little in their development, but their mobility is the only essential wherein they differ from other places inhabited by people in close proximity. With the exception of sewage disposal, the same sanitary principles apply to the car as to the house. Failure to appreciate this similarity has led to the promulgation of many useless and unnecessary laws and regulations, some having no relation whatever to sanitary science. The epidemic of regulations requiring the fumigation of cars at frequent intervals is dying down, and thorough mechanical cleansing with hot water and soap, the vacuum cleaner, and the air blast have been very properly substituted for this overworked sanitary rite. The present tendency is to require fumigation only after serious communicable diseases are known to have been carried, as is done by the new Interstate Quarantine Code. This is open to no objections; and even though the good it does is problematical, the railroad companies should incorporate the procedure in their own regulations.

An important duty of the railroads in relation to the communicable diseases is the instruction of their employees in the principles of prophylaxis, to make rules for their sanitary guidance, and to enforce these rules. The Pullman employees are supplied with a little pamphlet which explains in a brief and simple manner the origin of communicable diseases, their modes of transmission, and the reason for the existence of certain rules with which employees must comply. The pamphlet states in simple language what influence the actions of employees may have in aiding or preventing the indirect transmission of communicable diseases. The rules are only such as ought to apply in all railway service. They prohibit dry sweeping, dusting, and brushing, and the use of the common cup; they refer to the care of ice and water, to the cleansing of cuspidors, basins, and hoppers, and to the use of disinfectants and fumigation. The pamphlet also deals with such matters as heating and ventilation.

The sanitation of waiting-rooms is as important as that of cars. Many companies take pride in keeping their stations neat and clean. The stations of the elevated and subway lines in large cities are cleansed thoroughly at least once every twenty-four hours. In smaller places, however, the waiting-room, and especially the toilet, are frequently grossly offensive to sight and smell. Properly posted notices, embodying warnings and pleas to the traveling public, might help to alleviate this condition.

An unsolved problem of railway sanitation is the question of track pollution, which is potentially dangerous in two ways: the discharges may be washed from the tracks into bodies of water which are used for domestic supply, or they may dry, become pulverized, be blown up as dust by the wind or passing trains, scattered to the neighborhood, or blown into passing cars. The drainage from tracks may be much too direct for pathogenic bacteria to be destroyed in running streams; therefore, where reservoirs are near the railway lines, the drainage must be so arranged that contamination of the water supply will not occur. The danger from roadbed dust is largely theoretical. By the time that sewage has dried on the tracks, become reduced to dust, and carried into the air in a finely divided state, it is highly improbable that it often contains pathogenic organisms in a virulent condition. Motives of decency and esthetics, however, demand that the practice of the miscellaneous distribution of the excreta of passengers cease. Several devices have been patented for the holding of excrement from railway cars, but they have not been put into general operation, nor has their practicability been proven beyond question.

Infection by Contact. Obviously, the prime necessity in protecting travelers by rail is to keep out of cars all persons who are known to be infected with communicable diseases. This places the railroads in a difficult position, as they are under legal obligation to furnish transportation, and they have little power to discriminate among those who apply for it. Accommodation can be refused only under certain well-defined conditions, which in so far as the communicable diseases are concerned, must include a definite diagnosis, and this the railroads cannot be called upon to make. From the very nature of things the infected person is the one most likely to be informed, and legislation has been enacted placing the responsibility on the passengers themselves, and making it illegal for those afflicted with communicable diseases to ask for or to accept transportation from common carriers. Little attempt was made to enforce or to make known the various State laws on the subject, but the Interstate Quarantine Regulations now absolutely deny to all persons having the more dangerous and readily transmitted communicable diseases the right to enter public conveyances, and on all those with infections that are less readily transferred such restrictions are put as will render them innocuous to other travelers.

The following are the sections, with their amendments, of the Interstate Quarantine Regulations of the Treasury Department, designed to prevent and govern the interstate carriage of persons infected with the communicable diseases:

Section 1. For the purposes of interstate quarantine the following diseases shall be regarded as contagious and infectious diseases within the meaning of section 3 of the act approved February 15, 1893: Plague, cholera, typhoid fever, pulmonary tuberculosis, yellow fever, smallpox, leprosy, typhus fever, scarlet fever, diphtheria, measles, whooping cough, poliomyelitis (infantile paralysis), Rocky Mountain spotted or tick fever, anthrax, syphilis, gonorrhea, chancroid and epidemic cerebrospinal meningitis; and any person affected with any disease aforesaid, and anything, living or dead, which has been affected with or exposed to the contagion or infection of any such disease, except as otherwise provided in these regulations, shall be regarded as contagious or infectious until the contrary has been proven.

Section 17. Common carriers shall not knowingly accept for transportation from one State or Territory or the District of Columbia into another State or Territory or the District of Columbia any person suffering from any of the diseases mentioned in section 1, except as hereinafter provided.

Section 18. No person knowing that he is in the communicable stage of any of the diseases enumerated in section 1 shall travel on any car, vessel, vehicle, or other conveyance engaging in interstate traffic, except as hereinafter provided, nor shall any parent, guardian, physician, nurse, or other person allow or procure such transportation for any minor, ward, patient, or other person under his charge.

Section 21. Any person or thing, living or dead, which has been exposed to or infected with any of the diseases enumerated in section 1, if found in any car, vessel, vehicle, or conveyance undergoing interstate transportation, shall be subjected to such inspection, disinfection, or other measures as may be necessary to prevent the spread of the infection from them.

Section 22. In the event of the appearance of any disease mentioned in section 1, with the exception of tuberculosis, in any person *en route* or aboard any car, vessel, vehicle, or conveyance operating in interstate traffic, the common carrier shall at once isolate the sick person and remove him from the car, vessel, vehicle, or conveyance at the first convenient place at which reasonable provision may be had for the protection of the patient and the public health, and shall immediately notify the Surgeon General of the Public Health Service and the State and local health officer of the place at which the person was removed from such car, vessel, vehicle, or conveyance, and shall disinfect the compartment from which the person was removed.

Section 23. No person affected with plague, cholera, smallpox, scarlet fever, or yellow fever shall be received upon any car, vessel, vehicle or conveyance operating in interstate traffic.

Section 24. Common carriers shall not receive upon any car, vessel, vehicle, or conveyance operating in interstate traffic any person affected with typhoid fever, unless removal and entrance permits have been granted by the State or local health officers at places of departure and arrival, and unless said person is accompanied by a properly qualified nurse or attendant, and unless said nurse or attendant obligate himself or herself in writing, to the common carrier, to comply with the following regulations while in transit:

(*a*) 1. Communication with the compartment in which the patient is traveling shall be restricted to the minimum consistent with the proper care and safety of the patient.

2. All dishes or utensils used by the patient *en route* shall be placed in a 5 per cent. solution of carbolic acid or in disinfecting fluid of equivalent disinfecting value for at least one hour before being allowed to leave the compartment.

3. All urine, bowel movements, or other discharges from the patient shall be received into a 5 per cent. solution of carbolic acid or disinfecting fluid of equivalent disinfecting value, placed in a covered vessel and allowed to stand undisturbed for at least two hours after the last addition thereto; upon expiration of the time stated they may be burned, destroyed, or emptied into a common sewer at any convenient port or place.

4. Said nurse or attendant shall use all necessary precautions to prevent access of flies to patient, and after performing service of any nature to the patient shall at once cleanse the hands by thorough washing in a 2 per cent solution of carbolic acid or other solution of equivalent disinfecting value.

(*b*) Immediately upon the disembarkation of the patient the common carrier shall close the compartment the patient has vacated, without removal of any of its contents, and shall keep the same closed until disinfected.

Section 27. Common carriers shall not receive upon any car, vessel, vehicle, or conveyance operating in interstate traffic any person affected with diphtheria, measles, or whooping cough, or any person known to be a carrier of the bacillus diphtheriæ, unless removal and entrance permits have been granted by the State or local health officers at the places of departure and arrival, and unless said person is placed in a separate compartment and is accompanied by a properly qualified nurse or attendant and unless such nurse or attendant has pledged himself or herself in writing, to the common carrier, to comply with the following regulations while in transit:

(*a*) 1. Communication with the compartment within which the patient is traveling shall be restricted to the minimum consistent with the proper care and safety of the patient.

2. All dishes or utensils used by the patient en route shall be placed in a 5 per cent. solution of carbolic acid or disinfecting fluid of equivalent disinfecting value for at least one hour before being allowed to leave the compartment.

3. All sputum and nasal discharges from the patient shall be received in gauze or paper, which shall be deposited in a closed container and which shall be destroyed by burning or received in a 5 per cent. solution of carbolic acid or disinfecting fluid of equivalent disinfecting value placed in a covered vessel and allowed to stand for at least two hours after the last addition thereto.

(*b*) Immediately upon the disembarkation of the patient the common carrier shall close the compartment the patient has vacated, without removal of any of its contents, and shall keep the same closed until disinfection.

Section 28. Common carriers shall not receive for interstate transportation any person known by them to be suffering from pulmonary tuberculosis in a communicable stage unless said person is provided with the following articles:

(*a*) 1. A sputum cup made of impervious material and so arranged or constructed to admit of being tightly closed when not in use.

2. A sufficient supply of handkerchiefs, gauze or similar articles of sufficient size to cover the nose and mouth while coughing and sneezing. Said handkerchiefs, gauze or similar article shall be enclosed in a tight container after use and shall be destroyed by burning.

3. All sputum and nasal discharges from the patient shall be received in gauze or paper which shall be deposited in a similar container and which shall be destroyed by burning or received in a 5 per cent. solution of carbolic acid or disinfecting fluid of equivalent disinfecting value placed in a covered vessel and allowed to stand undisturbed for at least two hours after the last addition thereto.

(*b*) Immediately after the disembarkation of the patient the common carrier shall close the compartment the patient has vacated, without removing any of its contents, and shall keep the same closed until disinfection.

(*c*) Passengers in interstate traffic having pulmonary tuberculosis in a communicable stage shall not expectorate except in the sputum cup or gauze aforementioned.

Section 28—A. 1. Any person, infected with syphilis, gonorrhea, or chancroid, who wishes to engage in interstate travel, must first obtain a permit, in writing, from the local health officer under whose jurisdiction he resides. This permit shall state that, in the opinion of the health officer, such travel is not dangerous to the public health.

2. Any person, infected with syphilis, gonorrhea, or chancroid, who wishes to change his residence from one State to another must first obtain his release, in writing, from the local health officer. He shall inform the local health officer as to the place where he intends to reside and shall agree, in writing, to report in person to the proper health officer within one week after arrival at his new residence.

It shall be the duty of the health officer who issues the release to promptly notify the health officer under whose jurisdiction the infected person is to enter, of its issue. This release shall contain the name and address of the infected person.

The receiving health officer shall, in turn, report the arrival of the infected person to the health officer who issued his release and notify the State health officer of his State that a person infected with venereal disease has entered his jurisdiction.

3. Any person, infected with syphilis, gonorrhea, or chancroid, who wishes to engage in interstate travel or change his residence shall agree to continue treatment, under direction of a reputable physician, until the health officer shall have certified that he is no longer infectious. A certificate of noninfection shall not be issued until the health officer, or his accredited representative, shall have complied with the State board of health requirements for release of venereally infected persons.

Section 29. Common carriers shall not accept for transportation nor transport in interstate traffic any person suffering from or afflicted with leprosy unless there has been obtained from the Surgeon General of the United States Public Health Service, or his accredited representative, a permit stating that said person may be received under such restrictions as will prevent the spread of the disease, and said restrictions shall be specified in each instance: *Provided*, That in addition to the above, permits shall also be obtained from the health authorities of the States, Territories, or districts to and from which the patient intends to travel.

Section 30. No person knowing or having reason to believe that he is a leper shall accept transportation or engage in travel in interstate traffic unless permits have been obtained as set forth in the preceding section and unless said person shall have agreed in writing to comply with the restrictions as specified in the permits mentioned above.

SECTION 31. Any person who presents symptoms of leprosy and who is traveling or who has left the State where he resides in violation of the above regulations shall be detained and, if proven to be a leper, shall be returned to such State or removed to such Federal station as the Secretary of the Treasury may designate and the proper health authorities notified.

SECTION 32. For the purpose of these regulations the following shall be considered as the periods of incubation:

Disease	Days from last exposure
Plague	7
Cholera	5
Smallpox	14
Yellow fever	6
Typhus fever	12
Typhoid fever	14
Scarlet fever	7
Diphtheria	4
Whooping cough	10
Measles	14

SECTION 33. Interstate sanitary officers and State, Territorial, and other health authorities who will undertake to enforce the interstate quarantine regulations, as provided by section 3 of the interstate quarantine law approved February 15, 1893, shall notify the Surgeon General of the United States Public Health Service immediately, by telegraph and letter, upon the occurrence of a case or cases of cholera, yellow fever, typhus fever, or plague and shall render monthly reports as to the prevalence of smallpox, leprosy, scarlet fever, diphtheria, typhoid fever, poliomyelitis (infantile paralysis), epidemic cerebrospinal meningitis, Rocky Mountain spotted or tick fever, tuberculosis, and other diseases notifiable in their respective jurisdictions.

SECTION 34. Upon the occurrence of an unusual outbreak, or in the event of a sudden increase in the number of cases of smallpox, scarlet fever, diphtheria, typhoid fever, poliomyelitis (infantile paralysis), epidemic cerebrospinal meningitis, Rocky Mountain spotted or tick fever, or epidemic septic sore throat in any locality, the Surgeon General of the United States Public-Health Service shall be immediately notified by telegraph and letter of such unusual outbreak or sudden increase by the officers and authorities mentioned in the preceding section.

SECTION 37. Persons, firms, or corporations maintaining camps of migratory workers shall at all times maintain such camps in a proper sanitary condition and shall take proper measures to maintain the camps so occupied in a vermin-free condition and shall exercise such other precautions as shall prevent the interstate spread of disease from such camps, and the Surgeon General may from time to time detail officers or employees of the United States Public Health Service to make such inspections as shall be necessary for the enforcement of this regulation.

The overcrowding of street, elevated, and subway cars and in a lesser degree suburban steam railway cars is doubtless an important factor in the dissemination of diseases spread by oral and nasal secretions. During the pandemic of influenza in the Fall of 1918 the street railway traffic in many American cities, especially Washington, owing to war-time conditions, was so congested as to be a very serious menace to the public health. Various measures were resorted to in the hope of relieving the situation, but with very slight success. ''Staggered'' opening hours for the government offices were established, whereby the heavy traffic to and from the government buildings was distributed over several hours in the morning and evening. ''Jitney'' automobile lines were encouraged, and the owners of automobiles were asked to give the clerks and war workers free rides to and from their work. Conspicuous notices were posted in the cars warning people of the danger of coughing and sneezing without covering the face with a handkerchief. It is the firm opinion of the writer that the high morbidity which characterized the epidemic in Washington was largely due to this crowded condition of street railway traffic.

If infection by contact is to be avoided or minimized, ample provision must be made in all railway cars for travelers to keep their hands and faces clean. The lavatories should be supplied with an abundance of water, well drained and trapped, should have smooth surfaces for easy cleaning, and should be conveniently located. Individual towels should be constantly at hand and in sufficient quantity. A dental basin should be provided in all cars which make long journeys. If this is not done, the travelers will make a spittoon of the wash basin. The following sections of the Interstate Quarantine Regulations bear upon this phase of railway sanitation:

SECTION 7. Toilets and lavatories on cars, vessels, vehicles, or conveyances operating for the use of passengers traveling in interstate traffic shall be of adequate size, design, and number, and shall be maintained in a clean and sanitary condition.

SECTION 9. Common carriers shall not provide in cars, vessels, vehicles, or conveyances operated in interstate traffic, or in stations, waiting-rooms, or other places used by passengers traveling from one State or Territory or the District of Columbia to another State, Territory or the District of Columbia, any towel for use by more than one person: *Provided,* That towels may be used again after having been cleansed and sterilized with boiling water.

Toilets should be well flushed, susceptible of complete emptying and of easy cleaning, and be always available. The open hopper, seen on the older railway cars, is a sanitary anachronism and to be unqualifiedly condemned. It is constantly foul, and exposes the person of the user to the up draft of wind and dust.

Promiscuous expectoration should be minimized by the posting of warning signs in street cars. Steam railway cars should be provided with cuspidors and warning signs should be posted in day coaches. When cuspidors and toilets are disinfected, it should be done properly, preferably with steam or boiling water. The so-called drip "disinfecting" machine only adds an unpleasant odor to those already present.

SECTION 8. Common carriers by land or water while engaging in commerce between any of the several States or Territories or the District of Columbia shall take adequate measures by the use of warning signs or cuspidors, or both, for the prevention of the soiling of cars, vessels, vehicles, or conveyances with sputum, and said cuspidors shall be adequate in size and number and suitable in design for the reception of sputum, and shall be maintained in a clean and sanitary condition.

Day coaches should be provided with cans for garbage and refuse, as bits of food and other rubbish may be picked up from dirty floors or from cuspidors by children.

A distinct sanitary advance is the elimination of the common drinking cup. It would be well if the common comb and brush shared the same fate.

Section 10. Common carriers shall not provide in cars, vessels, vehicles, or conveyances operated in interstate traffic, or in stations, waiting-rooms, or other places used by passengers traveling from one State or Territory or the District of Columbia, to another State, Territory or the District of Columbia, any drinking cup, glass, or vessel for common use: *Provided,* That this regulation shall not be held to preclude the use of drinking cups, glasses, or vessels which are thoroughly cleansed or sterilized after use by each individual, nor shall it be held to preclude the use of sanitary devices for individual use only.

The cleanliness of cars and their equipment is very important, but the filthy habits of certain elements of the traveling public, especially on street railways, makes the task of the operating companies a difficult one. Many of the electric railways of this country maintain expensive and efficient cleaning systems, yet after a few hours of use the car is littered with rubbish, the floor is soiled with sputum, and the car is filthy in the extreme. The companies should maintain a sufficient number of cars so that they may be cleaned as often as they are dirty. The use of placards, notices, etc., will modify this evil to a certain extent.

The following sections of the Interstate Quarantine Regulations govern the cleaning of cars and the care of the bedding of sleepers:

Section 2. Common carriers by land or water, while engaging in commerce between any of the several States or Territories or the District of Columbia, shall maintain at all times in a clean and sanitary condition all cars, vessels, vehicles, or conveyances so being operated by them.

Section 4. Common carriers shall not permit, nor cause, to be cleaned any car, vessel, vehicle, or other conveyance operating in interstate traffic while the same is occupied by passengers, unless said cleaning is done in such manner as to prevent the distribution of dust.

SECTION 5. Any person, firm, or corporation supplying sleeping accommodations for passengers traveling in interstate traffic shall furnish the bed, couch, or other appliance used for sleeping purposes with clean sheets and pillow cases which have not been used by any other person since last laundered: *Provided,* That blankets, pillows, and mattresses which have not been used by any person suffering from a disease mentioned in section 1, if physically clean and free from vermin, may be used if they are so enveloped as not to come in contact in any way with any occupant of such bed, couch, or other appliance for sleeping purposes.

The following is a report made by Passed Assistant Surgeon A. D. Foster, U.S.P.H.S., of the methods of cleansing and disinfection of railroad cars as carried out by the Pullman and Southern Railroad Companies at Asheville, N. C., where most of the cars are presumed to be infected with tuberculosis.

Disinfection of Sleeping Cars. Upon arrival in Asheville, as soon as the passengers have disembarked, the car is shunted to a side track in the railroad yards. This track is used exclusively by cars undergoing cleaning and disinfection. On each side of the track is a platform several hundred feet long and built on a level with the floor of the car itself.

The ventilators and windows of the car are tightly closed, the berths are taken down, the blankets, pillows, and mattresses are spread out so that the formaldehyde gas may have access to the contents of the car. When this has been done, three galvanized-iron pails are placed on the floor of the car, one at each end and one in the center of each car. In each pail are placed 500 c. c. of commercial formalin and 250 grams of potassium permanganate, and the doors of the cars are tightly closed. The car remains closed for about twelve hours; the windows and doors are then opened to air the car and free it from the gas. All carpets, upholstered seats and backs, blankets, and pillows are removed from the car and placed on the platform in the air outside.

Dust is removed from the removable seats, backs, and carpets by means of compressed air, the force of which is so great that it removes practically every particle of dust. The carpets, seats, blankets, etc., are left out on the platform in the sun and air until the interior of the car is cleaned. The hose furnishing the compressed air is then taken into the interior of the car and dust is removed from every part of the interior by this means. A force of car cleaners is then put to work with buckets of hot water, and by means of soap and scrubbing brushes the floor of the interior of the car is cleaned, the woodwork being wiped off with damp cloths.

Drinking-water tanks are taken out on the platform, where they are cleaned. The water tanks are scrubbed inside and out with hot water and Sapolio, rinsed with clean water, and then placed over a steam pipe and sterilized with live steam. A small quantity of formalin solution is also placed in each spittoon.

Once a month the tanks used for storing water which is used for washing purposes in toilet rooms are flushed out and cleansed.

After the interior of the car has been thoroughly cleaned, the water tanks are replaced, and carpets, upholstered seats, pillows, and blankets are put back into the car, after having had a thorough airing in the sun. Owing to the care which necessarily must be used in washing woolen blankets, they are periodically shipped to special laundries experienced in this work, where they are washed and combed.

Besides the fumigation with formaldehyde gas, the toilet rooms are cleansed mechanically by scrubbing the floors with hot water and soap, and an acid solution is used to remove stains from the hoppers in the closets.

Cleansing and Disinfection of Day Coaches. If carpets are used in the car, they are removed from the car and carried out on the platform, where the dust is removed by means of compressed air. The upholstered seats are cleaned by the same means.

One of the places in a railroad car where dirt is frequently lodged is behind the steam pipes which run along both sides of the car. It is found that compressed air under a pressure of from 80 to 100 pounds is the best means of removing the dust which lodges in these places. On and behind these pipes is the place where passengers are apt to expectorate, and in order to cleanse these parts of the car thoroughly a hose delivering live steam is carried into the car and the pipes and the space between the pipes and the sides of the car are thoroughly steamed. After this has been done the floors of the car and the toilet rooms are scrubbed with soap and hot water. The hoppers in the closets are steamed and stains removed with a weak acid solution.

The drinking-water tanks are removed and scrubbed with hot water and Sapolio, both inside and outside, and are then steamed, care being taken that the hose does not come in contact with the interior of the tank.

Cleansing of Mail and Baggage Cars. Dust is removed from the interior of the car by means of compressed air after opening all doors and windows. The floors are scrubbed with soap and hot water, and the walls are washed down in the same way.

Carriers. This source of infection is an ever-present danger to the traveling public, especially in overcrowded street cars and suburban lines. Regulations segregating the known cases of communicable diseases from cars are only a partial protection to the well. Some chances must always be taken from those in whom infection is not apparent. The only hope for improvement in this feature of public assemblage lies in greater appreciation on the part of the public of non-promiscuity in personal relations and in the proper disposal of the body excretions and secretions.

Insects and Other Vermin. It is doubtful if it can ever be definitely known under just what conditions and to what extent railway cars may carry infected vermin. Doubtless both rats and ground squirrels gain access to freight-laden cars and are transported considerable distances, but this must be of rare occurrence, or plague would be widely distributed in the United States. In order to disseminate the disease in a new location it is necessary for the new arrival to meet and mingle with other animals while it is still infected, and railroad yards are not favorable places for such meetings. The danger is slight, but it cannot be disregarded. It is now possible to take this factor into account without serious hindrance to commerce, and plague-stricken districts are able to continue trade relations without danger to the outside world. The following section of the Interstate Quarantine Regulations provides for such contingencies:

Section 20. In the event of the appearance of human or rodent plague in any port or place within the United States, the Surgeon General of the United States Public Health Service shall establish such outgoing quarantine measures as will in his opinion prevent the introduction of the disease into another State or Territory or the District of Columbia: *Provided,* That freight which is known to have originated in rat-free surroundings and is shipped from rat-proof, rat-free warehouses, docks, or wharves, in rat-proof, rat-free cars, vessels, vehicles, or conveyances, may be granted pratique for interstate transportation when so certified by the Surgeon General of the United States Public Health Service or his accredited representative.

The following sections are designed to prevent the interstate transportation of the insect-borne diseases:

SECTION 19. No person, firm, or corporation shall offer for shipment in interstate traffic, and no common carrier shall accept for shipment, or transport in interstate traffic, any article or thing known to have been exposed to the contagion or infection of any of the diseases enumerated in Section 1, unless a certificate has been obtained from the proper health authority that all necessary measures have been taken to render such article or thing free from infection; and in the case of yellow fever, Rocky Mountain spotted or tick fever, or typhus fever, free from mosquitoes, ticks, or lice.

SECTION 25. In the event of the occurrence of a case of yellow fever *en route* or upon any car, vessel, vehicle, or conveyance operating for the transportation of passengers in interstate traffic, the case shall be isolated in a compartment or place so screened as to prevent the entrance or exit of mosquitoes, or their access to the patient; and the patient shall not be disembarked in infectible territory unless thoroughly protected from mosquitoes, and unless permission for such disembarkation has been obtained from the State and local health officials having jurisdiction over the place of disembarkation, and immediately upon such disembarkation the compartment vacated by the patient shall be fumigated in such a manner as to insure the complete destruction of all mosquitoes contained therein.

SECTION 26. Common carriers shall neither cause, permit, or allow to be hauled, removed, or transferred in interstate traffic any car, vessel, vehicle, or conveyance from a locality in which yellow fever prevails, unless there has been obtained from the Surgeon General of the United States Public Health Service, or his accredited representative, a certificate stating that said car, vessel, vehicle, or conveyance has been fumigated to destroy mosquitoes, or has been so safeguarded as to prevent the entrance of mosquitoes.

SECTION 36. During the period beginning March 15 and ending June

15 each year common carriers shall not accept for interstate shipment, and no person shall offer for interstate shipment, any cattle, horses, sheep, goats, elk, deer, or hogs, originating in a locality where Rocky Mountain spotted fever is known to exist, unless said shipment is accompanied by a certificate from a Federal, State, or local health authority, or an inspector of the Bureau of Animal Industry of the United States Department of Agriculture, or a State veterinarian or his deputy, setting forth that said animals are free of all attached wood ticks, or have been freed thereof by hand picking, spraying, or dipping in a disinfectant solution of sufficient strength and for a sufficient time to kill all ticks attached to the said animals, such hand picking, spraying, or dipping to be accomplished immediately prior to leaving the infected territory.

Food. In the dining-car service absolute cleanliness in the preparation and handling of food—especially milk, cream, and vegetables to be eaten raw—is important to the public health. Another important factor is the supervision of the health of dining-car employees with a view to excluding from the service those harboring the communicable infections. Cooks and waiters should be examined quarterly or semi-annually, and those found infected with tuberculosis, venereal diseases, typhoid, diphtheria, etc., should be dismissed or suspended until pronounced free from infection. The typhoid carrier must be carefully sought for, as he is an especially dangerous person in the kitchen. Every dining car should have a lavatory for the crew, and the management should see that it is always patronized and that the nails are properly manicured before beginning service. It would be well to inoculate dining-car crews against typhoid fever.

The food supplied on diners should be the purest obtainable, and should be handled in such a manner that it cannot become contaminated with human excretions. It must be carefully protected from flies during preparation and service. Drinking glasses and eating utensils should be scalded before they are served to patrons.

The following regulations govern the furnishing of food for the use of interstate passengers and for the transportation of food in interstate traffic:

SECTION 11. Persons, firms, or corporations engaging in the business of furnishing food or drink for the use of passengers traveling in interstate traffic shall not supply any article of food or drink, unless the same shall have been obtained from a source known to be free from the contagion or infection of the diseases mentioned in section 1, unless the same shall have been sterilized, pasteurized, or otherwise treated in such manner as to insure that the article is free from the danger of conveying contagion or infection as aforesaid; and all articles of food or drink for said passengers shall be so handled and stored as to prevent contamination with the said contagion or infection.

SECTION 12. After notification in writing by the proper health authorities, common carriers shall not transport, or accept for transportation, in interstate traffic, milk from premises on which there exists a case of cholera, scarlet fever, diphtheria, epidemic sore throat, or typhoid fever, unless said milk is accompanied by a certificate that it has been properly pasteurized under official supervision.

SECTION 38. After notification in writing by the proper health authorities, common carriers shall not transport or accept for transportation in interstate traffic, nor shall any person, firm, or corporation offer for transportation in interstate traffic, any oysters, clams, or other shellfish which have been grown, fattened, or handled in such a way as to render them liable to become agents in the interstate spread of disease, and the Surgeon General of the United States Public Health Service shall from time to time cause sanitary inspections to be made by officers of the Public Health Service of beds used for growing or fattening oysters, clams, or other shellfish and of shucking houses and other similar places in which oysters, clams, or other shellfish are shucked or otherwise prepared for interstate shipment, and he may forbid the interstate shipment of any such oysters, clams, or other shellfish which are produced or handled in a manner which will render them liable to become agents for the interstate spread of disease.

Water. The supply of drinking water must be ample as well as pure and wholesome. It should be stored and supplied in such a manner that it cannot be readily contaminated by passengers. The ice used for cooling the water should be pure and clean and must not be handled with bare hands.

Some States require the improved sanitary method of placing the ice and water in separate compartments of the cooler. The following are the regulations concerning water for drinking and culinary purposes provided on cars and vessels by interstate carriers:

SECTION 13. Water for drinking or culinary purposes provided on any car, vessel, vehicle, or other conveyance, by any person, firm, or corporation, while engaged in interstate traffic, shall conform to the bacteriological standard for drinking water, as promulgated by the Secretary of the Treasury on October 21, 1914, and shall not be from a supply that is exposed to contamination.

(*a*) The person, firm, or corporation before mentioned shall procure from the interstate sanitary officer, or the State or other health authority within whose jurisdiction the water is obtained, a certificate showing that the water supply conforms to the foregoing requirements. The aforesaid certificates shall be executed semi-annually, or as often as the Surgeon General of the United States Public Health Service may direct, and shall be filed with the United States Public Health Service.

(*b*) Ice used for cooling such water shall be clear, natural ice, ice made from distilled water, or ice certified as aforesaid, and before the ice is placed in the water it shall be first carefully washed with water of known safety, and handled in such a manner as to prevent its becoming contaminated by the organisms of infectious or contagious diseases: *Provided,* That the foregoing shall not apply to ice which does not come in contact with the water which is to be cooled.

(*c*) Water containers shall be cleansed at least once in each week that they are in operation.

(*d*) The provisions of this section shall also apply to water provided for drinking or culinary purposes on vessels plying between foreign ports on or near the frontiers of the United States, and adjacent ports in the United States, in accordance with article 4, Foreign Quarantine Regulations of the United States, promulgated October 20, 1910, and amendments thereto.

SECTION 14. No person, firm, or corporation engaging in interstate traffic shall maintain or permit to be maintained at or near any station or other ordinary stopping place over which the aforesaid person, firm, or corporation has control, any tank, cistern, receptacle, hydrant, pump, well, stream, brook, pool, ditch, or other place or article containing water which may be contaminated by organisms likely to cause a contagious or infectious disease, and which water may conveniently be obtained by employees of the aforesaid person, firm, or corporation, or by the general public engaging in interstate traffic, unless approved signs, prohibiting the use of such water for drinking purposes, be properly placed and properly maintained.

Air. Aërial infection, except in so far as droplet infection may be considered a phase of that subject, is a negligible factor in the dissemination of communicable diseases aboard railway cars. This, however, does not lessen the importance of good ventilation. A large amount of air enters running trains, due to the excessive wind pressure to which they are constantly subjected; therefore, with a simple exhaust system, specific air inlets are not necessary unless cars are greatly crowded. Natural crevices, with the addition of open sashes in the end doors, are sufficient. The proper control of heat is a more difficult problem than maintaining the air supply. Comfort is generally secured if the temperature is carefully regulated to between 65° and 70° Fahrenheit. For supplying artificial heat, direct radiation is better than indirect. Only when large quantities of cold air are admitted through one opening is the heating of the incoming stream desirable. This is not a good system for railway cars. In warm weather large streams of rapidly moving air from open windows are necessary for the comfort of passengers.

The dust, smoke, and engine gases that enter cars from time to time are never really troublesome except in passing through tunnels, when they produce some temporary discomfort. Repeated examinations of tunnel air have found the gases of combustion always below the danger point.

The generation of dust within the car should be limited by good cleaning, and by the prohibition of dry dusting, brushing, and sweeping while the car is occupied. When cleaning is well done and disturbance of car furnishings is avoided, carpets and plush are better than bare floors and smooth upholstery, because they hold the dust that settles on them and prevent its redistribution. (Crowder.)

The important source of dust is the roadbed. In hot, dry weather, when car windows must necessarily be open, this is very irritating. Sprinkling the tracks with oil controls this nuisance.

SECTION 6. All cars, vessels, vehicles, or conveyances operating for the use of passengers traveling in interstate traffic shall be so ventilated as to insure an adequate supply of fresh air.

Fomites. Passenger cars are now so frequently cleansed and disinfected that it is extremely improbable that fomites are of any moment whatever as factors in the dissemination of communicable diseases among passengers.

The possibility of the interstate transfer of anthrax by shaving or lather brushes is minimized by the following sections of the Interstate Quarantine Regulations:

SECTION 39. No person, firm, or corporation shall offer for shipment in interstate traffic, and no common carrier shall accept for shipment or transport in interstate traffic any shaving brush or lather brush unless manufactured in accordance with these regulations.

SECTION 40. Shaving brushes or lather brushes shall be made only from hair or bristles known to be free from anthrax spores.

SECTION 41. Unless hair or bristles are known to be free from anthrax spores before such bristles are made up into shaving or lather brushes, their disinfection shall be accomplished by one of the following methods: (*a*) By boiling the hair or bristles for not less than three hours; (*b*) by exposing the hair or bristles to steam under not less than 15 pounds gauge pressure for not less than 30 minutes with a preliminary vacuum of not less than 10 inches before turning on the steam; (*c*) by exposure to streaming steam for not less than six hours.

SECTION 42. All shaving or lather brushes shall be permanently marked with the name of the manufacturer or with a registered trade-mark in order to insure identification of the manufacturer and enforcement of these regulations.

Transportation of the Dead. The danger to the public health from the transportation of the dead is largely imaginary. It is living carriers, not dead bodies, that convey the infectious agents of disease. However, regard for public opinion and the possible danger from bodies dead of certain of the communicable diseases require that the transportation of the dead be subjected to official regulations. In 1913 the Conference of State and Provincial Boards of Health adopted the following regulations, which are only advisory until officially approved in each individual State and Province.

Rule 1. A transit permit and transit label issued by the proper health authorities shall be required for each body transported by common carrier.

The transit permit shall state the name, sex, color, and age of the deceased, the cause and date of death, the initial and terminal points, the date and route of shipment, a statement as to the method of preparation of the body, the date of issuance, the signature of the undertaker, the signature and the official title of the officer issuing the permit.

The transit label shall state the place and date of death, the name of the deceased, the name of the escort or consignee, the initial and terminal points, the date of issuance, the signature and official title of the officer issuing the permit, and shall be attached to the outside case.

Rule 2. The transportation of bodies dead of smallpox, plague, Asiatic cholera, typhus fever, diphtheria (membranous croup, diphtheritic sore throat), scarlet fever (scarlet rash, scarlatina), shall be permitted only under the following conditions:

The body shall be thoroughly embalmed with an approved disinfectant fluid, all orifices shall be closed with absorbent cotton, the body shall be washed with the disinfectant fluid, enveloped in a sheet saturated with the same, and placed at once in the coffin or casket, which shall be immediately closed, and the coffin or casket or the outside case containing the same shall be metal, or metal-lined, and hermetically and permanently sealed.

Rule 3. The transportation of bodies dead of any disease other than those mentioned in Rule 2 shall be permitted under the following conditions:

(*a*) When the destination can be reached within twenty-four hours after death, the coffin or casket shall be encased in a strong outer box made of good, sound lumber not less than seven-eighths of an inch thick, all joints must be tongued and grooved, top and bottom put on with cleats or cross-pieces, all put securely together, and be tightly closed with white lead, asphalt varnish, or paraffin paint, and a rubber gasket placed on the upper edge between the lid and box.

(*b*) When the destination cannot be reached within twenty-four hours after death, the body shall be thoroughly embalmed and the coffin or casket placed in an outside case constructed as provided in paragraph (*a*).

Rule 4. No disinterred body dead from any disease or cause shall be transported by common carrier unless approved by health authorities having jurisdiction at the place of disinterment, and transit permit and transit label shall be required as provided in Rule 1.

The disinterment and transportation of bodies dead of diseases mentioned in Rule 2 shall not be allowed except by special permission of the health authorities at both the place of disinterment and the point of destination.

All disinterred remains shall be enclosed in metal or metal-lined boxes and hermetically sealed, provided that bodies in a receiving vault when prepared by licensed embalmers shall not be regarded as disinterred bodies until after the expiration of thirty days.

Rule 5. The outside case may be omitted in all instances when the coffin or casket is transported in hearse or undertaker's wagon.

Rule 6. Every outside case shall bear at least four handles, and when over 5 feet 6 inches in length shall bear six handles.

Rule 7. An approved disinfectant fluid shall contain not less than 5 per cent. of formaldehyde gas, the term ''embalming'' fluid as employed in these rules shall require the injection by licensed embalmers of not less than 10 per cent. of the body weight, injected arterially in addition to cavity injection, and twelve hours shall elapse between the time of embalming and the shipment of the body. (Harrington.)

Chapter XIII

MUNICIPAL SANITATION

The Planning and Improvement of Cities and Towns

The scientific planning of American cities has long been neglected, and the result, in many cases, has been overcrowded slums and inaccessible suburbs. A well-planned city improves the social, ethical, and physical conditions of its citizens. The better hygienic system provides more light, purer air, and more healthful and less expensive living quarters, all of which react favorably on the public health. Conveniently located parks, recreation places, public baths, gymnasiums, and athletic fields provide increased opportunity for physical development. Safe and direct means of transportation prevent accidents and save time. The proper location of municipal markets affords cheap and wholesome supplies of food. These factors, with convenient location of schools, libraries, churches, and other structures of a public nature, all unite to place the life of the citizen on a higher plane.

Many of the ancient cities were magnificently planned, but it was not until the nineteenth century that the art, as we know it to-day, was practiced to any great extent. Most city planners have had to reorganize existing cities. L'Enfant, however, who planned the beautiful city of Washington, had the good fortune of having not only the support of the government, but an unencumbered site upon which to build. The planners of the industrial city of Gary, Indiana, also enjoyed the latter advantage. When Baron Haussmann rebuilt Paris he was given a free hand, and no expense was spared. Magnificent avenues were cut through the mazes of narrow streets of the old city and foul slums were replaced with parks and spacious squares.

The fundamental objects of the city are:

The housing of the inhabitants and their industries.

The conveyance of supplies and materials of manufacture and manufactured products.

The disposition of waste materials.

The arrangement of the city in an accessible manner, with rapid and convenient means of transportation.

The provision of facilities for education, assistance, and recreation for the common use.

To attain these objects the following principles and details should be considered when the city is planned or improved: The plan of the city as a whole, the segregation in suitable districts of the different classes of the population, and their proper housing in classes of structures suited to their requirements, the arrangement of such classes of structures in groups and district units, and the placing of such groups and units in proper relation to the whole; the development of other classes of units, such as civic centers, parks, public squares, grounds, athletic and recreation fields and cemeteries, and their location with reference to their uses and nature; the supplying of the units with the facilities and the public structures necessary for the business to be transacted in them; the location in civic centers of buildings suited thereto, both as to their uses and their architectural characteristics; the arrangement of systems of transportation, the laying out of streams of traffic, location of railway stations and bridges and harbor facilities; the systematic location of schools, libraries, churches, hospitals, institutions, theaters, and other semi-public structures; the general hygienic design of buildings and the system of city sanitation and waste disposal; the laying out of adjoining lands, woods, and fields for purposes of recreation, the artistic regulation of structures and street plans and the laying out of surrounding territory, all in accordance with a settled plan, adapted to fulfill in the best possible way the purposes intended and to take care of the growth of the city and prevent its abnormal development. (Koester.)

The Slum Problem. The slum is the enemy of the family, and as the primary function of the family is continuing the life of the species, the existence of the slum is a menace to the race. In the slum human misery is seen at its worst; there the predisposing conditions of the communicable diseases exist in their greatest intensity, and naturally the morbidity and mortality rates are much higher than in the less crowded districts. Not only are the overcrowding, darkness, filth, and vermin of the slums the constant causes of sickness and death among the inhabitants, but they are instrumental in maintaining permanent foci of infection that are a constant danger to the entire city. In times of epidemics, especially of the insect-borne diseases such as plague, typhus, and yellow fever, it is the slum that gives sanitarians the greatest concern.

The slum is as old as civilization; it is described by the classical writers of Greece and Rome, but the evil was vastly increased by the industrial changes of the nineteenth century, which concentrated millions of working people in large centers of population. The large city is here to stay, but the slum is not. The first serious efforts to improve the living conditions of the poor in large American cities were made in New York in the early fifties of the last century, when the Five Points were cleaned up and a movement started to build more sanitary tenement houses. The improvement has been more or less continuous since that time. In a number of instances great fires have been of indirect benefit to cities by destroying the slums, and thus permitting the rebuilding of the cities on more sanitary lines. Rome was a much finer city after its destruction and rebuilding during the reign of Nero; the Great Fire of London in 1666 was the best disinfection possible after the visitation of the Great Plague; the burning of Chinatown in the San Francisco conflagration of 1906 was a Godsend to that municipality.

The following are some of the measures now operating toward the elimination of the slum:

The destruction of the most insanitary blocks of tenements and the narrowest streets and their replacement with small parks and open squares. The passing of Mulberry Bend in New York City is an example of this reform.

The cleaning of the streets and the collection and disposal of refuse by the municipal authorities.

The establishment of municipal baths and wash-houses. The latter seem to have been more successful in Europe than in America.

The building of more public schools, which should have ample open-air playgrounds or roof gardens or both, and which should be for the people's use and not simply buildings in which to lock up children for a certain number of hours per week.

The building of sanitary tenements in compliance with the stipulations of wise housing laws. The establishment, in the larger cities, of a separate department in the municipal government to supervise, maintain, and inspect the tenement houses.

The following provisions of the New York tenement house laws show the progressive trend of recent housing legislation:

The definite restriction as to the percentage of the lot to be built upon, with stringent provisions as to the minimum size of yards, courts, shafts, rooms, window area, etc., so as to improve materially the light and ventilation of the tenement houses, and make it unprofitable for builders to erect houses on 25-foot front lots.

Increased regard for the safety of tenants in case of fires and the provisions about fireproof materials and the construction of houses; better and improved forms of fire-escapes; fireproof stairways, etc.; the restriction of non-fireproof buildings as to their height and number of stories; the prohibition of the occupation of tenement houses by businesses which are dangerous to life and health, etc.

The regulation of the occupation of cellars and basements, and prohibition of the location in tenement houses of stables, rag shops, etc.

The abolition of unsanitary plumbing fixtures like privy vaults and school sinks, and provisions as to the compulsory construction of separate water-closets in every apartment; also as to water supply in new and old houses.

Very stringent provisions for driving out prostitution from tenement houses, thus abolishing one of the greatest dangers of the growing population.

The registration of the names of all owners of tenement houses, and the application of the new principle of certification, i. e., that no tenement house newly constructed can be occupied without a previous certificate from the proper department stating that the house was constructed according to the law and is fit for habitation.

Water Supplies. Water supplies are discussed in the chapter on "General Prophylaxis."

Public Bathing Facilities and Swimming Pools. Many cities provide public baths, but they are seldom provided in sufficient number or with proper equipment. The shower bath is the best form for general public use, though tub baths and plunge baths have their place in public plants. The free bathing institutions should be located where they will be of the greatest benefit to the masses of people, and especially to those who cannot afford the luxury of a bath at home, as on the East Side in New York City. There should be no charge whatever for baths, the only requisite being respectable and orderly conduct on the part of the patrons, compliance with the rules, and that the bathers furnish their own towels and soap.

The more elaborate baths have large swimming pools, steam rooms, sweating rooms, shower baths, with both hot and cold water, and well-equipped gymnasiums, including running tracks. The baths should be supplied with as many features as possible, in order that they may be utilized to the fullest extent. They should be constructed throughout of tile and of such other materials as will betray the presence of dirt, in order that the most scrupulous cleanliness may be observed. Steam heat must be provided for keeping the water heated to the proper temperature, and also for keeping the rooms at a uniform temperature. The plumbing arrangements should be such that the swimming pool may be drained and refilled in a short time. This must be done frequently. The baths should be in charge of skilled swimming masters for the instruction of those who wish to learn to swim, and attendants should be available to massage those who desire such service.

The price of admission to these institutions, provided they are not free, should be just sufficient to cover the cost of operation. The fees for special service, as for massage and swimming lessons, should be turned into the general fund.

Many cities provide outdoor baths for use during warm weather. Floating baths moored in rivers or harbors are in use in most cities with available water-fronts. Some cities, as New Orleans and Boston, have shallow cement tanks, filled from the city water supply, built in parks and other open spaces for the use of the children of the poorer classes. It is needless to say that very material benefits are derived from their use during the hot summer months.

Separate municipal baths should be provided for women, but if this is not feasible, certain days of the week should be set apart for their exclusive use.

Communicable diseases are sometimes transmitted by the water of swimming pools and by infected towels and swimming suits. Typhoid fever, diarrheal conditions, inflammatory infections of the upper respiratory tract and conjunctiva, injury and inflammation of the ears, venereal and skin diseases have, on reasonably reliable evidence, been traced to public and private swimming pools and to those of colleges and universities. The larger the tank, the less the danger. The water should have an initial purity equal to that of safe drinking water. In some of the best athletic clubs the water is filtered before being run into the tank. If the water supply is limited, it may be cleaned by refiltration. It is better, however, that the tank be frequently emptied and refilled with water fresh from the source of supply. If deemed necessary, the water may be disinfected by chlorination. When this is practiced the disinfection should be continuous, or at least most effective at the time the pool is in use, as the bathers constantly pollute the water by urination and expectoration and occasionally infect it. An excess of hypochlorite in the water is irritating to the eyes. In some out-of-door pools it may be occasionally necessary to use sulphate of copper to prevent the excessive growth of algæ.

Bathers must be required to take a shower bath with a liberal use of soap before entering the tank, and, theoretically, inspected for disease and instructed in pool sanitation. The employees of the bathing plant should be under sanitary supervision and the towels and bathing suits should be sterilized by boiling or steaming after each use.

Public Comfort Stations. In the matter of public water-closets and urinals American cities are sadly behind those of Europe, and there is no reasonable excuse for this deficiency. Public comfort stations containing well-kept sanitary water-closets, urinals and lavatories for both sexes should be installed in the business sections of large cities and in the public squares and parks. These should be under the care of janitors and matrons who are held responsible for their cleanliness. A desirable feature is the provision of closets having a greater degree of privacy to which patrons are admitted on the payment of five cents, sometimes by coin slot devices. This includes the use of a towel for use in the lavatory after leaving the closet. Placards bearing warnings as to the dangers of venereal diseases, advice regarding cleanly habits and other matters of personal hygiene are placed to advantage in public comfort stations.

Barber Shops. Skin diseases, especially the parasitic diseases, and other affections may be acquired in barber shops. The shops should be frequently inspected by the health authorities. No person affected with a communicable disease, particularly a venereal disease, should be permitted to act as a barber.

The following provisions should govern the sanitation of barber shops:

The shops, together with all the furniture and equipment, should be kept in a clean and sanitary condition. They must be well ventilated and provided with running hot and cold water.

All instruments and utensils such as razors, scissors, clipping machines, pincers, needles, mugs, and shaving brushes should be sterilized, preferably in boiling water, after each separate use. Combs and brushes should be thoroughly cleansed with soap and water after each separate use.

The barbers shall thoroughly cleanse their hands immediately before serving each customer.

Alum or other material used to stop the flow of blood should be applied only on a clean towel or other clean cloth.

The use of powder puffs and sponges should be prohibited, except that a sponge owned by a customer may be used on him.

The hair cut from the heads of customers should be swept up immediately after the customers leave the barber chairs.

No barber shop should be used as a sleeping room.

Sewage Purification and Disposal. Sewage consists of household effluents and wastes, including the feces and urine from water-closets and the waste water from lavatories, sinks, wash-tubs, laundries, etc.; the liquid excreta from stables; industrial wastes such as the foul effluents from abattoirs, breweries, and dyeworks; water used for public purposes, e. g., watering streets, fountains, public urinals, baths, etc.; rainfall, of which the first portions from streets are extremely foul; subsoil water, and at times small natural streams. The composition of sewage is complex and variable, but the following are practically always present in it: sodium chloride, ammonia, carbon monoxide and dioxide, hydrogen and ammonium sulphide, fetid and decomposing organic matter, and myriads of bacteria. The air of sewers ("sewer gas") has no constant composition, and if the sewer be properly constructed, well ventilated, and sufficiently flushed, may differ but little from outside air. If the sewage is allowed to stagnate, the air of the sewer becomes foul; oxygen is lessened, carbonic acid increased, and there is much organic matter, together with variable quantities of marsh gas, sulphureted hydrogen, and ammonium sulphide. The properties of the organic matter are similar to those of the organic matter in respired air. Protracted exposure to an atmosphere contaminated by sewage emanations results in anemia, depression, and general ill-health, which predispose to the communicable diseases.

As microörganisms adhere to moist surfaces, the air of well-constructed sewers is, on the whole, remarkably free from them, except near fresh-air inlets and at junctions, where splashing occurs. Neither bacteria nor other solid particulate matters are, under ordinary circumstances, given off from quiescent liquid surfaces; but if fecal putrefaction occur the bursting of bubbles may recharge the air with them. In many cases it has been found that the air of well-constructed sewers contains fewer bacteria than the air of the street above, and the species found were mostly not of sewage origin. It thus becomes probable that sewer gas can rarely, if ever, convey pathogenic organisms. (Whitelegge and Newman.)

Sewage is of prime importance to sanitarians, as it is always a source of danger to the public health, and its removal and disposal present greater difficulties than do those of any other class of refuse or waste. It should be removed from human habitations as soon as possible after production, as the danger increases with the amount of putrefaction undergone. The *water-carriage* system of sewage disposal is in general use in American cities. It is undeniably the best system, especially if all the constituents of sewage are to be disposed of collectively. Where the topography of the city does not permit of natural drainage, the *pneumatic* system may be used to advantage. In this method air-tight pipes extend from the dwellings and other buildings to reservoirs from which the air is periodically exhausted and the sewage thus drawn into them. It is seldom successful, as there is constant danger of breaks in the pipes and consequent destruction of the pneumatic action. The *Shone* or *ejector* system is a modification of the pneumatic system, and is more practical and successful. The sewage is conducted by gravity through suitable drains to convenient ejector stations or tanks, whence it is forced by means of compressed air to the irrigation fields or other places of ultimate disposal. (Egbert.) This system is in successful operation in Manila.

Where house refuse only is to be considered, and where the waste-water can be kept from the other parts of the sewage, or where the water supply, physical conditions, or the cost of constructing sewers prevent the use of the water-carriage method, the *pail* or *earth closet* system, or else primitive privy-vaults or cesspools must be used. These methods are discussed in the chapter on "Rural Sanitation."

The water carriage system comprises the house fixtures, pipes, and drains and the public sewers which receive the sewage from the house-drains and carry it to the place of final disposition. The house fixtures include water-closets, urinals, bathtubs, wash-basins, laundry tubs, sinks, etc. The best materials for making sanitary house fixtures are enameled iron and porcelain, although cast iron, soapstone, and even wood were used formerly. The fixtures are connected by branches to several vertical pipes running through the house, each serving a special purpose. The "rain leader" runs outside of the house and collects the rain from the roof; the "waste pipe" runs vertically through the house and connects with all kitchen sinks and laundry tubs and wash-basins; the "soil pipe" is the main vertical pipe to which the water-closets and sometimes the bathtubs are connected. These vertical pipes join in the cellar to the inclined main pipe, called the "house drain," into which all the sewage and waste liquids from all fixtures and pipes are discharged. The house drain runs through the cellar and joins the street sewer by a short connection called "house sewer," which connects the house drain in front of the house with the sewer in the street. (Price.)

The admission of sewer gas into a house is prevented by means of appliances called "sewer traps" placed between the house fixtures and soil-pipes and drains or sewers. Many traps are too complicated. The simpler a trap the better, provided it have sufficient "seal," which is the depth of water or the mechanical appliance which prevents the back-flow of gas. The S or siphon trap is as simple and efficient as any, is of uniform diameter throughout, has no corners or projections to catch dirt, and is thoroughly cleansed by each fair flow of water through it. The value of a trap does not depend so much on the amount of water it contains as on the depth or strength of the seal. Traps may be unsealed by evaporation of the water through disuse, forcible ejection of seal through momentum and force of flush, or loss of seal through waste paper, etc., being left in trap and emptying the water by capillary attraction. The water is sometimes lost by "siphonage,'' or by the action of a large column of water descending with great momentum down the vertical pipe with which the trapped fixture is connected, such force being sufficient to siphon out the seal, or contents of trap. (Price.) The water of a seal may become foul by constant and long contact with the foul air in the pipes, which is under increased pressure due to heat and decomposition within the pipes.

Evaporation is prevented by frequent use of the fixture, or by filling the trap, when not in use, with oil. Loss of seal by momentum and capillary attraction can be prevented only by care in the use of the fixture and flushing apparatus. Fouling of the seal and siphonage are prevented by ''vent'' or ''back-airpipes'' which run through the house vertically and are connected by branches to the crown of every trap of every fixture. These pipes furnish to each trap a column of air which may be drawn upon in lieu of the seal, and prevent fouling of the water in the seal by providing an escape of the air under pressure. ''Non-siphoning traps'' may be used instead of vent pipes. These are made and shaped so as to contain a large amount of water, which may be difficult or impossible to empty by siphonage.

The water-closet is the most important house sanitary fixture. The bowl and trap should be made of porcelain in one piece, with smooth surface and capable of being easily cleaned. The wash down, siphon, and ''dececo'' are the best types. Water-closets are not flushed directly from the water service pipe for fear of contaminating the water supply. They are flushed indirectly from tanks placed above them, which tanks are automatically filled and emptied by pulling a chain or raising a lever lifting a plug out of the socket and flushing through a flush pipe into the closet. Several appliances are on the market which dispense with the separate tank, and at the same time prevent a direct connection with the water-supply pipes.

It is impossible to discuss here the details of house drainage and plumbing. For these matters the reader is referred to works on general hygiene and sanitary engineering.

Sewers are the conduits that receive and carry the contents of house and other drains to the place of final disposal. Two types of sewers are in general use—the *combined* and the *separate*. The first type has heretofore been most commonly used in American cities. It is constructed to carry off all kinds of sewage, the waste and excreta from houses, the effluents from factories, street washings, and surplus rain water. A combined sewer must have a capacity sufficient to convey the greatest probable rainfall upon the area drained in addition to the other sewage, therefore the depth of the usual daily volume of the latter will be shallow and the current sluggish. This favors the settling of the solid and semi-solid constituents, the obstruction of the sewers, and the development of bacteria and sewer gas. These faults are obviated and a more rapid flow secured by constructing them egg-shape in section, with the smaller end downward. Combined sewers are more expensive to construct and keep in repair and are more difficult to ventilate than the separate type. The separate system involves the construction of two sets of sewers, one for the sewage proper from houses and occasionally from small factories, and another sewer or channel for rain water, surface water, soil water, and factory wastes. In this system the volume of sewage carried is comparatively small and constant, and can be calculated from the daily water supply and population; the sewage is more concentrated and uniform in composition, hence can be better utilized as fertilizer or otherwise disposed of; the sewers are smaller and have smoother walls, therefore they are more frequently and effectually flushed. The disadvantages of the separate system are that a community must have two sets of drains, and that after a protracted dry season the street washings, factory wastes, etc., may become very foul; these are more than balanced by the advantages enumerated above.

The following description of sewers is abridged from Whitelegge and Newman's "Hygiene and Public Health":

Sewers. Sewers are impervious tubes, oval or round in section. Their size varies according to requirements, say from 9 inches to 12 feet in diameter. If the diameter is not greater than 1½ or 2 feet, glazed earthenware pipes set in cement are usually employed. Sewers of larger diameter than 18 inches are generally constructed of brick set in cement upon a bed of concrete, and are oval or ovate in section, so as to secure a better scour and less friction when little sewage is passing than if the section were circular. Sewers should be laid as far as possible in straight lines, with means of inspection and access at every change of direction. All junctions should be obliquely in the direction of flow, and the tributary sewer or drain should have a fall into the sewer at least equal to the difference in their respective diameters. It is desirable that the rate of flow should be not less than 2 feet per second, and 3 feet is better. Hence the minimum gradient should range from 1 in 250 to 1 in 750, according to the size of the sewer. The gradient should preferably be uniform, except at angles and junctions, where it is desirable to allow extra fall.

Manholes should be provided at short distances, and at all important angles, junctions, and changes of gradient, to allow of access for inspection and flushing. Flush-tanks may with advantage be placed at the head of each sewer. Flushing is chiefly required in sewers with insufficient gradients, at "dead ends," and in hot, dry seasons, when the flow is smallest and decomposition most rapid. It may be effected more or less automatically by means of flush tanks, or by temporarily damming back the stream and then allowing it to escape with a rush, or by suddenly discharging a large amount of water into the sewer through a manhole. Little benefit is likely to result from the perfunctory "flushing" of sewers that is commonly practiced, consisting as it does of simply pouring a small and inadequate volume of water into the sewer through a hose, at intervals of several weeks. There is little to be gained by the addition of "disinfectants" to the water used for flushing.

Sewers must be ventilated in order to avoid the risk of the pent-up gases forcing their way into houses through traps. Openings are provided for this purpose at intervals which should not exceed 100 yards. For combined sewers the inlets for street washings and rain water, located at street corners, etc., are usually sufficient. If these are not close enough together to keep the sewer atmosphere constantly changing and reasonably pure, other means, such as grated openings in the roadway, should be provided.

In some cities the sewers are ventilated by allowing a free flow of air from the sewers through the house drains, the individual house fixtures only being trapped. This converts every house drain and every soil pipe into so many sewer ventilators. It destroys the drain isolation between each house, which is now possible from the sewer, and from the neighboring houses of the district. The method is apparently safe, assuming that the house plumbing is of substantial character and kept in good repair.

"By the term *sewage disposal* is understood any method by which the sewage of a community is conveyed from its vicinity directly or indirectly into a convenient waterway, such as a river, canal, or the sea, without any reference whatever to its purification other than what the processes of nature may effect; and by the term *sewage purification,* the removal from the sewage in a more or less efficient manner of those impurities which have been contributed to otherwise more or less clean water, and the restoration to a waterway of an effluent which consists more or less of clean water." (Glaister.) Until recent years it had been the almost universal practice in this country to discharge the sewage without treatment into the nearest stream, lake, or harbor. If the dilution is sufficient the public health is not endangered, but by abuse of this method water supplies become polluted, oyster beds are infected, and in extreme cases the streams become practically open sewers. The self-purification of sewage-contaminated rivers by oxidation, subsidence, fish, animalcules, and saprophytic bacteria is slow and uncertain, and it is not safe to depend altogether on this phenomenon, as was formerly done In no case can there be any certainty of the destruction of pathogenic organisms, a consideration that is especially important when the stream furnishes the water supply of districts lower down. Nevertheless, the property of self-purification of natural bodies of water and the power of rivers to remove suspended matters should be utilized so far as is consistent with safety. No universal standard of permissible pollution can be set; there is a limit for each river which is governed by the use that is made of the river, character of the sewage, etc. When there is any danger of the pollution becoming so great as to affect the public health, the sewage must be purified before being discharged into the stream or lake. The minimum amount of unpolluted water required to dilute safely the sewage of 1000 people is given by Egbert as 2,000,000 to 4,000,000 gallons per day, and by Rosenau as 2.5 to 4 cubic feet per second in streams. Slow-running streams and those receiving industrial wastes, such as oily matters which retard oxidation, require more water.

When sewage is discharged into lakes the relation between the sewer outfalls and the intake of the water works must be carefully considered, and the dispersion of sewage by currents induced by wind and temperature must be studied.

Many coast cities dispose of their sewage in the sea. It is allowed to escape only with the ebb tide, and reflux is prevented by valves. If it is conducted by pipes sufficiently far out to sea, it may not be washed back by currents or by the returning tide to foul the shore. The effects of the tides upon the sewage must be carefully studied when sewers empty into harbors.

The public health is protected against infected water supplies by means of filtration of the polluted waters and by purification of sewage. The doctrine is now established that water filtration is superior to sewage purification as a means of protecting water supplies against infection. Water filtration is described in the chapter on "General Prophylaxis."

Appropriate treatment will theoretically remove or oxidize most if not quite all of the putrescible organic matter and kill or remove most of the bacteria contained in sewage. Generally the purification is incomplete, the degree of purification attained depending upon local conditions. Sewage purification was originally practiced in Europe in order to secure an effluent that could be discharged into waterways without causing gross pollution. Some cities have placed greater importance on the destruction or removal of pathogenic bacteria with the object of protecting oyster-beds, bathing beaches, or reducing the "load" on water filters. According to the particular needs of the situation the degree of purification varies all the way from a nearly complete purification down to a mere straining out of the grosser solids. (Whipple.)

The following methods are in general use for the purification of sewage: (*a*) Chemical; (*b*) Filtration; (*c*) Irrigation; (*d*) Biological; (*e*) Combinations of the foregoing.

Chemical. This method is sometimes applied as the sole method of treatment, but it is best adapted for use as preliminary to other methods. Various combinations of iron, lime, magnesium, and alumina are the chemicals employed. The mixture chosen is added in fixed quantities to the sewage, which is then run into tanks, where it is allowed to stand until precipitation has taken place. The precipitate consists of the chemical reagents and the solid matters of the sewage and is known as sludge. Usually the sewage is passed through screens or grids to remove the larger masses of feces before the chemicals are added. In addition to screening the sewage it is frequently allowed to settle in special settling tanks before the chemicals are introduced and the mixture is run into precipitation tanks. When precipitation is complete the effluent is run off and the sludge removed and mixed with the gross materials filtered off by the screen and deposited in the settling tank. The sludge may be pressed into cakes and used as manure, cremated, buried, or dumped into the sea.

A good chemical process rapidly clarifies the sewage by removing all, or nearly all, the suspended impurities, and carries down more or less of the dissolved organic matter. The effluent is fairly clear, but contains the chlorides and certain other salts, ammonia, and some of the dissolved organic matter. It is necessary to subject the effluent to filtration or biological treatment in order to oxidize the remaining organic matter. Chemical precipitation is not certain to remove pathogenic or saprophytic organisms, and furthermore it creates large quantities of sludge. The chemical processes are particularly useful for sewage containing industrial wastes. While they are applicable to large cities, and are capable, when worked properly, of effecting a high degree of purification, they are very costly in installation and maintenance.

Filtration. Intermittent downward filtration requires a porous soil, underdrained by porous pipes at a depth of from 4 to 6 feet. The area should be as small as will absorb and cleanse the sewage, not excluding vegetation, but the produce is of secondary importance. The land to be used must be laid out in plots and dug up to form alternate ridges and furrows. The ridges should be about 18 inches in height and about 5 feet apart. The sewage to be treated is distributed over the surface by means of the furrows or trenches, controlled by sluices, so that each plot or bed receives the sewage for a few hours, and each has intervals of rest. The sewage is purified by the action of vegetation planted upon the ridges and as a result of bacterial action and filtration through the soil. The filtering area of ground required is at least 1 acre per 1000 of population unless the process is secondary to chemical treatment, when 1 acre per 2000 may be sufficient. The percolated fluid which constitutes the effluent is conducted by artificial channels into a water course. The solids are incorporated into the soil by ordinary agricultural operations, and thus a soil is made rich for the growth of crops, such as hay, cabbages, turnips, etc.

The extent of land necessary for large cities, coupled with the high cost of preparation and maintenance, makes this process inapplicable for other than small towns.

Irrigation. In broad or surface irrigation the sewage is conveyed to a sloping piece of ordinary agricultural ground, and is distributed over the surface by means of channels in which its flow can be diverted where wanted. Porous soil is to be preferred. If the soil is not porous it should be underdrained. When naturally sloping land is not available, wide ridges 20 to 40 feet apart must be made. The sewage is distributed over each portion of the ground intermittently, by means of the branching channels, which pass along the ridges or along contours of slopes at intervals of about 20 feet. The sewage is oxygenated in flowing over the slope from the channels, and the organic matter is broken up by the action of bacteria in the superficial layers of the soil. The sewage is screened before distribution, unless it has been subjected to preliminary filtration or precipitation.

Subsoil irrigation is a modification of this process, the sewage being delivered through porous drains a few inches beneath the surface of the soil.

The water which percolates through the soil ultimately finds its way into natural water courses, just as does the rain. The crops grown on "sewage farms" are wholesome in every respect, and there is no objection to their use as food, provided the vegetables are not sprinkled with sewage water.

The amount of land required for this method is considerable, about 1 acre to every 300 of the population, therefore it is applicable to small towns only. It is apt to fail in times of severe rainfall and frost, and the area of irrigation is liable in warm weather to become objectionably odorous. The successful operation of broad irrigation requires the closest supervision.

Biological. Biological methods of sewage treatment are dependent on aerobic and anaerobic organisms present in the sewage itself. Two systems are in use, the *aerobic* or contact-bed method, and the *anaerobic* or septic tank method.

Contact beds are large water-tight tanks filled to a depth of 3 or 4 feet with some such porous material as coke, cinders, burnt clay, or gravel; loose-jointed tile drain-pipes are laid along the bottom to carry off the effluent. Such beds act partly mechanically as strainers and partly biologically. The surface should be raked from time to time to assist oxidation. The beds become more efficient after being used some time, as they thus become impregnated with the right kinds of bacteria. After filling, the beds remain undisturbed for two hours, the sewage then passing to a second bed of finer material or to a filter bed, and the contact bed is given a rest of four hours in order to allow aeration to take place. This process may be controlled by automatic filling and emptying valves. Frequent and prolonged periods of rest are necessary; without them the beds become clogged, and eventually inactive because lacking in aerobic bacteria. The sewage should be freed more or less from solid matter by screening or sedimentation before being applied to the beds. Half an acre of bed is required for every 1000-1500 population.

The *trickling, percolating, sprinkling* or *continuously aerating filter* consists of broken stones, clinker, and gravel, enclosed in a strongly built wall provided usually with openings for the aeration of the filtering material. Underdrains are laid on a tight floor beneath. The sewage, freed from solids, is fed or sprayed on to the surface of the bed slowly and steadily by means of some automatic arrangement such as a revolving sprinkler, and percolates through the filtering material to the underdrains. The object of this process is to change the character of the organic matter by oxidation so as to render it non-putrescible. The suspended matter is not permanently retained in the beds, but is carried out in the effluent, which is turbid and requires subsequent clarification.

"The rate of application varies from 500,000 to 2,000,000 gallons per acre daily, one acre of trickling filter serving a population of 10,000 or more. Well-operated sprinkling filters receiving the effluent from plain sedimentation or septic tanks are capable of removing from 85 to 90 per cent of the suspended matter and from 90 to 95 per cent of bacteria, yielding an effluent that is non-putrescible. This method is useful when sandy areas of suitable size are not available or are too expensive. The subsequent clarification of the effluent from trickling or sprinkling filters may be satisfactorily accomplished by the addition of chlorinated lime and passage through a settling basin of moderate size." (Egbert.)

Treatment in contact beds may be used as a preliminary to filtration or other treatment, or as a secondary to septic tank treatment, or to filtration through a rougher filter if the filtering material is very fine. The filters require occasional periods of rest.

In the septic tank method advantage is taken of both the anaerobic and aerobic bacteria which are abundant in all sewage that is not too strongly impregnated with antiseptic chemical wastes. The purpose of the septic tank is first to make use of the disintegrating action of the anaerobic bacteria upon the undissolved organic matter before subjecting the sewage to the action of the aerobic bacteria which it contains. Therefore it is advisable to precede either filtration or irrigation by treatment in the septic tank.

A *septic tank* is a long, narrow tank of sufficient size to retain the flow of sewage from eight to twenty-four hours or longer, the velocity of flow being about one-half inch per minute. The sewage is allowed to settle in grit chambers or settling tanks before entering the septic tank. This collects most of the street sand and other inorganic solids. When the sewage enters, part of the solids fall to the bottom, while part remains on the surface, where a thick scum rapidly forms. The sludge is allowed to remain in the tanks for a long time, thus permitting intensified bacterial action under anaerobic conditions. This solidifies and gasifies some of the solid organic matter and reduces the amount of sludge. Considerable gas is evolved, which causes a continual motion of the suspended sludge. From 10 per cent to 40 per cent of the solid organic matter of the sewage is digested by this process. The effluent from a septic tank is entirely fluid and comparatively clear, but it must not be allowed to enter a stream until it has undergone oxygenation and has been purified by filtration or irrigation. Septic action cannot be depended upon to render sewage safe as far as infections are concerned. (Rosenau.)

Septic tanks for the digestion of sludge only are known as digestion tanks. They are deep tanks divided by sloping partitions into upper and lower compartments. The sludge reaches the lower compartment through openings in the partition walls and is there retained for septic action or digestion, while the main body of the sewage flows through the upper compartment and is not retained. In this type of septic tank the sludge alone undergoes septic action, and the products of decomposition do not mix with the flowing sewage. The sludge is smaller in bulk and dries more quickly. This is an important consideration when treating the sewage of large cities.

Disposal of Refuse. The solid waste material not carried by municipal sewers is known as "refuse," and includes ashes, garbage, rubbish, street sweepings, manure, and dead animals. In a large city the amount of refuse to be disposed of is very great, its character and quantity varying with the seasons.

The amount of ashes is greatest in winter and that of garbage in summer. The proper disposal of refuse is not as important as the proper disposal of sewage, nevertheless it has an important bearing on the public health. Flies will breed in garbage cans that are not regularly cleaned, as they will in accumulating manure. The bottles, cans, etc., in rubbish afford breeding places for mosquitoes. Ashes and street dust irritate the eyes and respiratory passages and predispose to microbic infections.

The removal and disposal of refuse form part of a well-arranged municipal sanitary system. Until recently refuse was usually removed by contract, and its disposal in the case of cities located on a stream or on the sea was accomplished by simply discharging it into the water course, or by dumping it far out at sea. The refuse of some inland cities, for which no other method of disposal seemed available, was spread on fields in the country. In many cases these methods proved to be highly objectionable. Most cities now dispose of refuse either by cremation in furnaces or destructors, or by reduction by steam heat, whereby marketable products such as grease and powdered manures are obtained, the sale of which partly covers the cost of the process.

The method of cremation, incineration, or destruction in furnaces or destructors is the one most generally used in Europe. All the municipal refuse, including ashes, garbage, and market refuse, house dirt, and wastes from stores and shops, is burned together, the combustible material in the rubbish and the unburned coal in the ashes usually being sufficient to evaporate the water in the garbage, so that the material is self-consuming.

Destructors are supplied with forced draft capable of maintaining a temperature of 2500° F. or more. They usually consist of three or four contiguous grates which are fired at different times. The smoke, flames, and gases pass through a large combustion chamber, and the heat is utilized for the generation of steam, and, after passing the boilers, to heat the incoming air supply. The power generated may be used for various local purposes about the works, but a large surplus is frequently available for other uses, such as electric lighting, electric transportation, and the pumping of water and sewage. In many cases this surplus power furnishes a considerable financial return and contributes to the economy of this method of disposal. The clinker ashes which form the residue from destructor plants may be sold or utilized for the construction of sidewalks or for making concrete.

Properly constructed and operated destructors are odorless and can be located in populous districts, which materially reduces the cost of haulage. Furthermore, where destructors are used, a careful separation of garbage from other wastes is unnecessary, and all household wastes may be deposited in the same receptacle. This is known as the mixed system of collection and disposal of municipal refuse.

The reduction of garbage is the method of disposal in use in most large American cities, though disposal by cremation is extending in the United States. The garbage, rubbish, and ashes are kept separate by the householder and collected in different wagons. This is the separate system of refuse collection and disposal. At the reduction plant the garbage is sorted to remove foreign substances, such as tin cans, glass bottles, etc., and then cooked in digestors by steam under pressure of about 60 pounds for from six to ten hours, after which the grease is extracted by pressure and sold for commercial purposes, while the solid portion, known as tankage, is dried and sold for use as fertilizer.

It is almost impossible to conduct reduction works without creating a nuisance, therefore they should be located at a distance from populous districts. Objectionable odors may be materially reduced by passing the offensive air from the more objectionable processes through deodorizing furnaces of suitable capacity with combustion chambers in which heat of 1200° F. is maintained at all times.

The collection of garbage from a sanitary standpoint and from the standpoint of nuisance is a difficult problem. It is usually collected in water-tight carts, and transported to the reduction works in water-tight cars or vessels so as to retain all the free liquid for the recovery of by-products. Mixed collection can be carried on with less nuisance than separate collection. The water of garbage mixed with ashes in a single can is absorbed by the ashes, the odor is reduced, and fewer flies are attracted, and the dust nuisance is reduced. Mixed collection is the most economical, as fewer carts are required and collections can be made at longer intervals.

Disposal of garbage to farmers is objectionable, as it involves cartage over miles of road in wagons that generally leak and permit the escape of nauseous odors, to the great annoyance of dwellers and travelers along the route.

In some small cities garbage is fed to hogs owned by the municipality. The garbage should be sterilized with steam and the feed supplemented with grain. This is a sanitary method if the garbage feed is stopped a few weeks before the hogs are killed. Garbage for hogs must be collected frequently and the piggery must be managed carefully or fly and other nuisances will be created.

Some large cities have incineration plants to dispose of the great combustible accumulations from the commercial districts. A simple furnace connected with an ordinary stack is usually sufficient, and such works can be operated in populous districts without objection. Garbage and other refuse containing putrescible organic matter cannot be disposed of in such furnaces.

Street Pavements and Cleaning. City streets not only serve for purposes of intercommunication and traffic, but provide light and air to the adjacent houses. Incidentally they are utilized as receptacles for a network of underground pipes, conduits, and wires which afford drainage and sewage facilities and furnish gas, heat, light, steam, and electric power, telephone service, etc., to the buildings. Streets should not be dusty in dry weather, nor muddy and impassable in wet seasons. A good city street pavement should have quick surface drainage, good foundations, impermeability and hardness of surface, avoidance of slipperiness, least resistance to traffic, cleanliness and noiselessness. From a sanitary point of view impermeability and noiselessness are the most essential requirements. The incessant noise of vehicles passing over rough stone pavements affects the nervous system and indirectly reduces the duration of life.

From a sanitary standpoint asphalt is the best pavement, especially for streets with light traffic. It is water-tight and quite impermeable; it prevents soakage into the subsoil; it is free from the noxious odors so often found on pavements with joints; it is durable, smooth, and very readily cleaned; it renders the traffic noiseless, does not cause jarring or vibration of buildings, and creates no dust due to abrasion and wear. Its only disadvantage is its liability to become slippery when the pavement is damp or greasy, as during foggy weather, or where soft mud is carried to it from adjoining stone pavements, by horses' hoofs, pedestrians' shoes, and carriage wheels. It is principally adapted to the residential parts of cities, where there is no heavy traffic; owing to its noiselessness it is also preferred in the neighborhood of courthouses, schools, and hospitals. (Gerhard.)

Footpaths and sidewalks are paved with flagstones or with artificial stone, with bricks laid flat, or with asphalt. They should be laid so as to afford good drainage into the gutters, and should be constructed so as not to become slippery. Gutters should be constructed with care, to avoid leakage of storm water into the subsoil and into the cellars of houses. (Gerhard.)

There is no advantage in well-paved streets if the pavements are not thoroughly cleaned at regular and frequent intervals. In the broadest sense of the term, street cleaning includes sweeping the roadways, sidewalks, and gutters, the collection and removal of the road dirt, the sprinkling of streets, the removal of snow, the cleaning and disinfection of public conveniences, the cleaning and flushing of sewer catch-basins, and the removal of house refuse. Many factors, such as the character and material of the pavement, the width of the street, the density and class of population, the nature and amount of the traffic, the condition of the weather, etc., control the quantity and composition of street dirt. It is composed chiefly of abraded particles of stone, wood, iron, and shoe leather; gravel, sand, or mud from the subsurface; horse dung and urine of animals, mixed with house refuse, ashes, street and yard sweepings, more or less garbage, dead leaves, and other vegetable matters. Of late years, since the passing of the horse car and the coming of the electric car and the automobile, the amount of horse-dung on the streets has materially decreased.

Uncleaned streets are direct and indirect sources of danger to the public health. The possibly infected dust and dirt blown about by the wind at least predisposes to infections of the eyes and the respiratory passages; it is blown into houses and settles on the skin and clothes of persons, on furniture, draperies, curtains and carpets. Windows are kept closed to avoid this, hence houses are not properly ventilated. Flies will surely breed in the manure and other organic filth allowed to remain on uncleaned streets.

The roadways are cleaned by scraping, sweeping, washing, and flushing. The sweeping may be done by hand labor with brooms or brushes, or by the use of mechanical street cleaners —the latter being far the best method. Streets should be sprinkled before sweeping to avoid stirring up dust and dirt. Horse-droppings on important thoroughfares should always be swept up at once and removed in sacks or bags. Many sanitary engineers do not approve of washing the filth and dirt into gutters and catch-basins, and thence into the street sewers, except in special instances, preferring dry removal of the street dirt in large covered carts.

Snow which accumulates on sidewalks and on footpaths should be cleared off by the adjacent householders under penalty of a fine. The owners of vacant lots and unoccupied houses should also be compelled to clean the sidewalks in front of their property. Street railroad companies should be required to remove the snow piled up by the snowplows outside of the tracks. The disposition of the snow removed from the streets is sometimes a difficult problem. It may be dumped into rivers, canals, or harbors, or thrown into the sewer manholes. The snow from frequented thoroughfares is mixed with street mud and road scrapings, hence the former method may be objectionable, as it causes silting up of the watercourse or harbor. If the second method is adopted, the sewers should be simultaneously flushed with large quantities of water to prevent the deposition of mud.

The use of salt to hasten the melting of snow on sidewalks and car tracks is objectionable, as it causes a deep slush which is conducive to cold and dampness, ruins clothing and shoes, injures horses' hoofs, and chills the feet of pedestrians, thus predisposing them to pneumonia and other respiratory diseases. This method should be used only when the slush is at once swept into the street gutters. The same criticism applies to the melting of snow by the use of fires and steam jets, which at best is a slow and expensive proceeding.

Street sprinkling should be considered as a part of the general street-cleaning system, as traffic and pedestrians as well as the owners of property bordering on the street benefit by it. The streets should be sprinkled in summer time and in dry weather during other seasons. It cools the air in hot weather, and keeps down the street dust; the air is washed of impurities, and a feeling of relief is experienced similar to that after a shower.

Streets are usually sprinkled by means of watering-carts or vans, but they may be watered from hose jets attached to hydrants. The latter method is particularly adapted for well-kept streets with impermeable asphalt pavements.

Sidewalks should be kept neat and clean; mud should not be allowed to accumulate, as it tends to make sidewalks slippery. Snow should be promptly removed and ice should be covered with sand and ashes to prevent accidents and damage suits. Street cleaners should pay particular attention to street crossings, which should be cleaned, swept, and the mud raked off, and in winter the snow should be removed from them first, so as to avoid delay in street traffic.

Filthy street gutters may be a source of danger to the public health, particularly in hot weather. They should be kept unobstructed and swept daily to secure a proper drainage of the street surface, and be kept impervious, to avoid leakage into the subsoil or into cellars, and they should have a continuous grade to the nearest sewer inlet. No pools of stagnant, offensive liquid should be allowed to accumulate. Gutters and inlets of catch-basins should be kept clear after snowfalls, in order to avoid flooding when a thaw occurs.

Smoke and Gas Nuisances and Prevention. Smoke impairs the health directly and indirectly. It directly irritates the mucous membranes of the respiratory passages, and probably predisposes to pulmonary diseases, including tuberculosis. Smoke is a source of dirt, and the mineral acids contained in it have a corrosive influence upon inorganic substances and are injurious to plant and animal life. It obscures the light, depresses the spirits, and soils with soot. Windows will not be opened in a smoky atmosphere, hence houses and other buildings will not be properly ventilated. The economic waste and damage resulting from the smoke nuisance are enormous.

The problem of smoke prevention has been taken up by a number of cities and is being dealt with successfully. The nuisance is greatest where soft coal is used, but with a proper furnace receiving intelligent attention the emission of black smoke is totally unnecessary. The main essential of the improved furnaces adopted in power plants and factories is the provision of ample space between the fire and the boiler or other surface to be heated, in which the gases resulting from the burning of the coal may be fully consumed before they strike the colder surface of the boiler or other object above, which would condense them into the form of black smoke. Improvements in methods of stoking and the use of mechanical stokers also tend to increase the consumption of smoke. Factories should be equipped with boilers of sufficient power so that they need not be forced, as this is a prolific cause of smoky chimneys. The more general use of electricity generated by water power and the electrification of railways is having a tendency to decrease the smoke nuisance.

Research by sanitary engineers has demonstrated the fact that the ordinary gas supply is to-day a constant menace to the public health, attended as it is not only by numerous fatalities, but by many non-fatal poisonings and various obscure consequences of the leakage of illuminating gas in private dwellings, public halls, and streets. This is seldom thought of and even more seldom detected, but it doubtless plays a part in diminishing vital resistance and increasing susceptibility to the communicable diseases. Apparently an increased danger was introduced with the increase in the proportion of the more dangerous modern water gas as compared with the old-fashioned coal gas. Two lines of public health control are indicated: first, limitation by law of the percentage of the dangerous constituent, carbon monoxide; second, measures to prevent the leakage of gas in buildings and streets. State legislative action is needed for the first, but the local health authorities attend to the latter through gas inspections. These require standards for the construction of gas fixtures, so as to eliminate cheap and faulty fixtures, and supervision of the installation of gas piping and fixtures. The inspections of piping and fixtures should be regular, especially in tenements and public buildings, to locate leaks and cause them to be repaired. Attention should be paid to possible leaks in entering mains underneath houses, from which gas may rise and permeate the house air. (McNutt.)

Markets. The term "market" is here used in a restricted sense as designating the buildings intended for the sale and purchase, at certain hours daily, of food products. City markets are usually built by the municipality, and some of them, especially in Europe, are beautiful specimens of architecture. They should be built in a substantial and thoroughly sanitary manner, preferably of brick or stone, or of iron and glass; wooden structures are very undesirable. If possible, market buildings should be entirely detached and should be placed on open squares, with ample provision for easy access of vehicles. The halls should be well lighted and ventilated, but not draughty; they must have plenty of floor space and storage room and have numerous exits, passageways and driveways. All driveways should be well paved and drained. Wholesale markets require suitable arrangements for loading and unloading trucks and wagons, and rail connections for the prompt receipt of provisions coming from long distances. Retail markets are located in or near the most densely populated districts of the city, so as to be easily reached by the public and small trades people.

Markets are closely related to the provision of healthful food supplies, and to a proper and efficient food inspection. Covered markets are a development of the nineteenth century, and have many sanitary and utilitarian advantages over the open markets of former times. The merchants and buyers are protected from inclement weather; provisions can be better exhibited and exposed for inspection and sale, and are not so liable to be damaged by heat, cold, rain, snow, dust, dirt, and smoke. City markets enable buyers to obtain fresh provisions daily, the buying and selling are rendered more convenient, prices are better regulated, and in many cases cheaper than in stores, owing to reduction in running expenses and rent. They also facilitate the thorough supervision and efficient inspection of the food supply by the health authorities. Under this supervision waste and refuse are promptly removed and the surrounding streets kept clean. Street traffic and the safety of pedestrians are better maintained in the vicinity of covered markets than on streets and squares used as open markets.

Woodwork should be avoided in market hall interiors, for obvious sanitary reasons. The walls should be finished with a non-absorbent material to a height of at least 6 or 7 feet. To this end they may be faced with glazed bricks, or they may be lined with white tiles, or else they may be simply plastered with hard plaster or cement, which is often painted with light-color enamel paint. The floor should be constructed of cement, asphalt, or hard-burnt paving brick. It may also be paved with large slabs of marble, or be tiled, preferably with a rough tile, which does not become slippery. If the buildings have cellars for the storage of provisions, they should be arched over and the floors made waterproof, and finished either in asphalt or in cement, or with asphalt or hard-burnt paving blocks. Elevators in addition to stairs should be provided to move the food supplies to the cellar.

Well-equipped market buildings are provided with numerous large refrigerators and artificially cooled rooms for the storage of meat, poultry, eggs, and other perishable food products. The waste pipes for the melting ice must be properly and safely disconnected from the soil pipes and the sewer, as meats, fish, milk, and other foodstuffs are spoiled by sewer gas.

For the maintenance of cleanliness in market buildings a plentiful supply of water and suitable devices for the flushing of the floors and the washing of walls must be provided. There must be well-trapped and sewer-connected drainage openings in the floor. Numerous hydrants and taps with rubber hose connections must be installed for flushing out the drainage openings and washing the floors. There should be separate and well-kept toilet rooms for both sexes.

Market halls are generally ventilated by means of high side windows, fitted so as to swing on a horizontal axis, or else by raised ridge roofs with louvre windows. Good ventilation is of great importance in market buildings, not only on account of the large number of visitors, but also on account of the necessity of removing the strong odors from some of the supplies, such as fish, cheese, etc., and finally because fresh air is necessary to maintain the food in a good condition. The buildings must be heated in cold weather. Artificial lighting is necessary on dark winter mornings. Ample illumination is a safeguard against the possible sale of food that has begun to putrefy and also against uncleanliness.

In order to maintain sanitary cleanliness and healthful conditions the floors and passageways of markets, as well as the surrounding streets, must be kept scrupulously clean, and decomposing animal and vegetable food should be removed at least once daily. During hot weather the floors should be frequently flushed and disinfecting or deodorizing liquids applied from time to time.

Covered galvanized-iron receptacles should be used for the collection and removal of market refuse, such as bits of food, butchers' offal, etc. The refuse should be removed from the buildings in water-tight covered carts; open carts are objectionable.

Warning notices should be posted in markets forbidding the handling of food by prospective customers. This applies especially to meat and meat products.

Abattoirs. In former times slaughtering was done in yards or butcher shops scattered throughout the various districts of a city, and it was almost impossible to exercise a proper control of these private establishments. From a public health point of view it was desirable to secure a more careful and strict control of the live animals as well as of their meat, hence the movement toward concentration of this important industry in central abattoirs. The slaughter of live stock at butcher shops is uneconomical and unsanitary. The following are some of the sanitary evils connected with this method: lack of adequate slaughtering facilities and mechanical equipment; the difficulty of a proper meat inspection; the danger to the public health arising from the possible sale of diseased meat; the unsanitary and offensive conditions of the slaughter houses, due to lack of facilities for cleanliness; the improper disposal of the animal waste matters, resulting in nuisances, bad odors, and in soil, air, and water pollution. These evils are removed and overcome by the erection of central abattoirs or slaughter-houses in the outskirts of the city, and the legal abolishment and prohibition of all small private slaughtering places in the populous districts. Among the advantages arising to a city from the establishment of central public abattoirs may be mentioned the following: Offensive odors and disagreeable noises connected with the killing of the animals are abolished or reduced to a minimum; better facilities are afforded the butchers for the humane killing of the animals and the dressing of the meat under the constant superintendence of qualified inspectors; the meat does not so readily spoil, as better facilities exist for storage and for the maintenance of cleanliness; the sanitary inspection of the animals before slaughtering and of the meat after killing is facilitated and performed in a more efficient manner; central abattoirs facilitate the disposal, prompt removal, or commercial utilization of the waste products of slaughtering; in case of epizoötics, there is better control of the animals to be slaughtered.

Large public abattoirs are built by municipalities, by butchers' associations or corporations, or by private individuals or firms. Municipal ownership, as is the rule in Europe, is the preferable method, as the slaughtering of animals and the inspection of the meat involve sanitary problems which should be under the control of the health authorities. The very large abattoirs, as in Chicago, from which meat is shipped in interstate commerce and to foreign countries, are under Federal inspection. Cleanliness and sanitation can be more efficiently enforced when the plants are owned by the city. In this case the city derives a considerable revenue from the rent of the slaughter stands or stalls to the butchers.

A public abattoir should be located in the outskirts of the city, on a site that is isolated, yet easily accessible from all sides, never in or near the residential districts. Water supply, drainage, and traffic connections by rail or water or both must be assured. If the plant is located on a river it should be put below the town, and should be easily accessible to the country highways if cattle are raised in the adjoining rural districts. When the cattle markets or stock yards are in immediate connection with the large abattoirs, the sanitary inspection of the meat supply is facilitated and rendered more efficient. Large stock yards should be equipped with a disinfecting plant for the disinfection of the cattle cars.

A large abattoir is composed of a number of buildings, sheds, stockades, etc. Stables, pens, and large sheds must be provided for the animals, and the cattle, calves, sheep, and pigs are generally kept separate. Large abattoirs usually have separate slaughterhouses for each group of animals. The carcasses are dressed and cleaned in other buildings, and later stored in cold storage plants. Special buildings are provided for diseased and suspected animals. Still other buildings are devoted to the commercial utilization of the offal, such as fat rendering and bone boiling, and to cremators or destructors for condemned meat. The administration building contains the general offices, rooms for the sanitary inspectors, for the veterinary surgeons, and laboratories for the microscopical examination of pork. There is usually a separate power plant and a complete refrigerating and ice-making establishment.

The buildings in which the by-products, such as blood, hides, tallow, bones, intestines, and hair, are treated must be kept under proper sanitary supervision. The noxious vapors and gases, arising from the cans and kettles of rendering establishments, must be made to pass through condensing-tanks and then under the fires of the boilers, and be finally discharged through the tall chimney of the power plant.

The main slaughtering hall may be a large open and undivided room, in which all the different butchers work together, or it may have two rows of smaller killing compartments, arranged one on each side of the central aisle, each compartment being rented out to one or to several butchers. The former plan is preferable from a sanitary standpoint, as it facilitates official supervision of the work and cleanliness is more readily secured.

The outer walls of slaughter-houses should be built of either brick or stone, or else of iron with glass sides and roofs. The buildings must be strong and durable, and it is essential that the inside walls to a height of 6 or 7 feet from the floor should be rendered impervious, smooth, and easily washable, so that dried blood and scraps of flesh adhering to them can be readily removed by means of hot water and soap. The walls may be faced with light-colored glazed brick, or else they may be tiled with white glazed tiles. A cheaper method is to coat the brick walls with asphalt varnish, and any wooden posts or partitions should be treated with this composition.

The floors of a slaughter-house must be solid, non-absorbent, impervious to moisture, hard, and durable, but they should not be too smooth or slippery. Asphalt, concrete, roughened bluestone, hard-burned brick laid on edge in cement or concrete, and double layers of Georgia pine planks, calked and made water-tight after the manner of a ship's deck, are all in use and all have their advocates. The floors should be graded and sloped to floor drains. The blood is some-

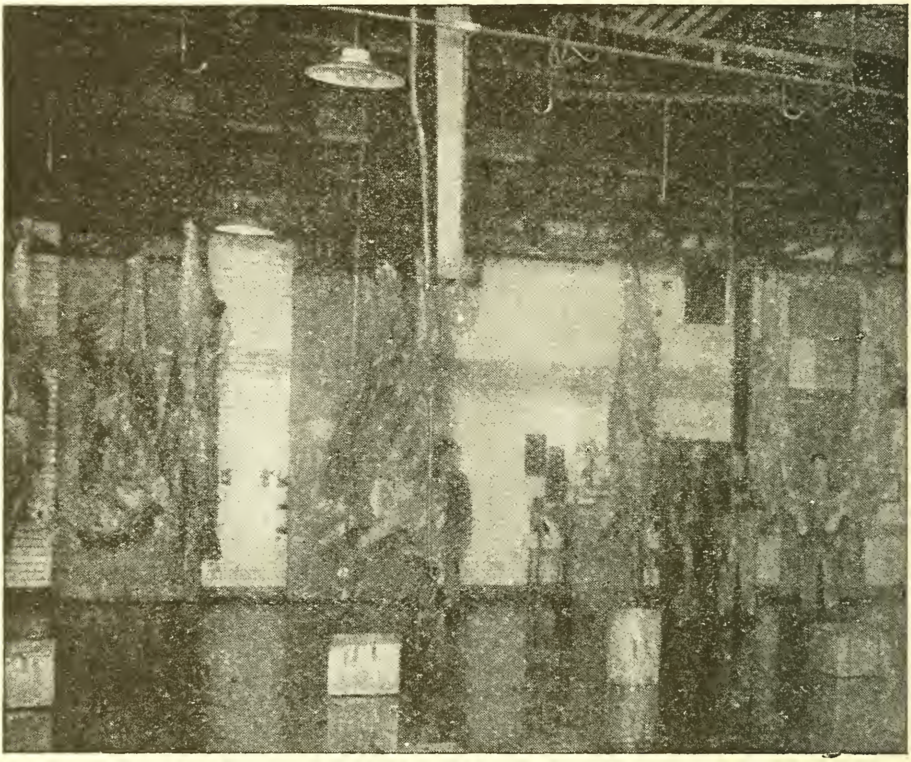


Fig. 27.—Interior of a Model Abattoir.
The walls are tiled. The floor is sloped for flushing. (*Courtesy New York City Department of Health.*)

times carried in special floor troughs or gutters to special receptacles.

A liberal supply of water is required for the operation of abattoirs. It is required for the watering and washing of the animals, for the washing and flushing of floors and walls, for the sprinkling of roadways, for fire protection, and for the condensers of the refrigerating plant. The water may be obtained from the mains of the city water works, or, if the abattoir is located at a distance from the city limits, it sometimes becomes necessary to provide a separate water-supply system. A system of mains should be installed in all the buildings, with plenty of taps, and hydrants not only at the troughs and other plumbing fixtures, but for flushing, sprinkling, fire protection, and other hose use. Hot water is required in large quantities, particularly for the cleaning of the intestines of the slaughtered animals and for the baths and lavatories of the employees.

A good drainage system is essential for the proper sanitation of abattoirs. In large plants the separate system is used to advantage, the storm water from the paved yards and roadways and from the roofs being carried off in one set of mains and the waste water from the slaughtering halls, toilets, bathrooms, etc., in the other. The sewage from abattoirs should be purified before being discharged into a water course. The various mechanical, chemical, or biological methods or a combination of two methods are employed.

Large windows are necessary in the buildings to assure good daylight illumination, for the maintenance of cleanliness and for the careful inspection of the meat. Electric light or gas is used for artificial illumination. Many of the large establishments have their own electric lighting plants.

Sanitary toilet rooms for both sexes should be provided. Shower baths for the use of the butchers should be installed near the large slaughtering hall.

Ample ventilation is required in the pens and stables, in the killing halls or compartments, and in the buildings where the meat products are prepared. Artificial heating is not usually required in the large killing halls, but the offices, laboratories, toilet rooms, restaurants, etc., should be suitably heated in cold weather, preferably by steam. High-pressure steam is required for disinfecting purposes.

All sources of odors that may contaminate meat must be eliminated from abattoirs. The buildings must be kept free from rats, mice, flies, and other vermin. Dogs should not be permitted around slaughter-houses on account of the danger of parasites, especially trichinosis. The offal should not be fed to hogs.

The employees of abattoirs must be of cleanly habits, and their outer clothing should be of washable material. Their boots and shoes must be kept clean. The hands must be washed before beginning work and after visiting the toilet. Persons with communicable diseases, particularly tuberculosis, should not be permitted to work in any part of the establishment where meat or meat products are prepared or handled. After handling a diseased carcass butchers should thoroughly cleanse the hands of all grease and then disinfect them with a reliable chemical disinfectant. The knives and other implements used on diseased carcasses must be sterilized by boiling water or in a strong disinfecting solution and thoroughly cleansed before they are again used. Meat that is contaminated by falling upon the floor or in other manner must be removed and condemned. The water and ice used in the preparation of the carcasses should be pure and wholesome, and the trucks and cars and all surfaces with which the meat comes in contact must be kept clean and in good sanitary condition. The skin and hoofs of animals condemned for tuberculosis and other diseases (except anthrax) transmissible to man, may be used provided they are immersed for not less than five minutes in a 5 per cent solution of aqua cresolis compositus or a 5 per cent solution of carbolic acid or a 1/1000 solution of mercuric chloride.

Lodging Houses. Unless carefully supervised and frequently inspected by the police and health authorities, lodging houses become centers of infection of the communicable diseases. Smallpox cases are frequently discovered in them. In times of danger from the louse-borne diseases their sanitary supervision is especially important. Plague is apt to appear first in the low lodging houses along the water front.

The following measures, compiled from the sanitary codes of New York, Boston, and other cities, have been found applicable for the proper sanitation of lodging houses:

No license should be granted until the board of health has certified that the building is provided with a sufficient number of water-closets and urinals, and with good and sufficient means of ventilation. The board of health should require the licensee, from time to time, to cleanse thoroughly and disinfect all parts of the building and furniture, particular attention being paid to the eradication of insect vermin.

The means of light and ventilation should be satisfactory to the board of health and beyond the control of lodgers. Not less than 500 cubic feet of air space should be allowed to each lodger in sleeping rooms.

Open and spacious dormitories are to be preferred. All bedsteads should be single and of iron. There should be not less than 2 horizontal feet between the sides of any two beds. Blankets should be required and "comforters" should be prohibited. Mattresses should be covered with a waterproof covering. No person should be allowed to retire or sleep in his day clothing. No person who is not clean should be allowed to retire without a bath.

Water-closets (one to every twenty lodgers), lavatories and shower bath, with hot and cold water, all with open plumbing, should be furnished on each floor, and the floors of the same should be of marble, slate, or concrete. All movable receptacles for excretions should be prohibited.

Smoking in sleeping rooms should be prohibited.

Happily the old style of lodging house is becoming a thing of the past. The introduction of the cheap yet cleanly hotel, of which the Mills Hotel is the prototype, has done much to eradicate the dens of iniquity and foci of infection. The self-respecting person who is short of funds may now find a place in most cities to lay his head, get a bath and a square meal without danger of moral and physical contamination. The Salvation Army, the Young Men's Christian Association, the Young Women's Christian Association, the Young Men's Hebrew Association, the Knights of Columbus, and other organizations have done much for the welfare of the floating population. During the Great War their canteens, dormitories, and huts protected the young soldiers, sailors, and marines from many moral and physical evils.

There are, unfortunately, in all large cities, a number of the honest, homeless, who are unable to pay for a bed even in a ten-cent lodging house. These human beings must be cared for, and the municipal lodging house seems the only available solution. The police station lodging rooms in New York, which were closed by Colonel Roosevelt when Commissioner of Police, were vile, vermin-infested dens in which the homeless were herded, without pretense of bed, bath, or food. They were parodies on municipal charity and veritable breeding places of vagrancy. Many large cities now conduct cleanly lodging houses in which the unfortunate man or woman receives a compulsory bath, a decent place to sleep, and breakfast. Experience has shown that if measures are taken to set such of the patrons to work as really want it, and send the rest to jail as vagrants, the number of lodgers is surprisingly small.

City Parks, Squares, Playgrounds and Recreation Piers. Parks have been well called the lungs of a city. In them and in the smaller open squares the dwellers in apartment houses and tenements breathe the fresh air and receive the sunshine that fails to reach the narrow streets and courts. The benefits to the public health of a city derived from the possession of such a park as Central Park in New York City are beyond estimation. American cities, as a rule, have not been sufficiently appreciative of the necessity and desirability of adequate park systems. Usually they have been satisfied with a few small, dusty squares in the business section and certain large stretches of ground on the outskirts, principally useful for picnic parties and athletic sports. A park system should be laid out in a broad spirit and with liberality, and space should not be spared. It is easy to reduce a park in size, but it can be increased only at great expense.

The park system of a city should be laid out in a systematic manner, and should consist of parks of varying size and design, each more or less particularly adapted for certain purposes. They should, broadly speaking, increase in size with the increase in distance from the business district, and there should be four or five classes of parks. Those of the smallest size should be located in the most congested portions of the city to relieve the pressure of traffic and business. Parks of the next largest size should be in the crowded residential districts, and they may be of varying sizes, from one to four blocks or more in area. These are the parks where the children are brought or come for their daily airing and recreation. Parks of the third class should be located on the outskirts of the residential portions of the city, and may be very large, from twenty to several hundred acres in extent. These should be the principal parks of the city and should be connected by boulevards and parkways. They generally contain driveways and bridle-paths, lakes for boating in summer and skating in winter, bandstands where concerts are given, restaurants, zoölogical and botanical gardens, athletic grounds for baseball, football, tennis, etc. The fourth and largest group of parks generally consist of large undeveloped areas of land, owned by the city and rented out, partially for farming uses and partially held as forests, from which the wood may be cut and sold in such quantities as will not deplete its growth. (Koester.)

The number and location of the parks should be such that every portion of a city is within easy walking distance of at least a small park. Parks should be so placed as to be part of a system, and not merely set down at haphazard and wherever room may be made. This is well exemplified in the beautiful circles and squares of the city of Washington.

Desirable features in the park system are gymnasiums, athletic fields, comfort stations, shelter houses, recreation piers, driveways, and floral decorations.

The sanitation of city, suburban, and rural recreation parks and picnic groves is becoming an important factor in the public health, as millions of people annually seek relaxation in these open spaces. Many parks and groves are situated at the headwaters of streams, therefore the proper disposal of human excrement is a great question, especially to those people living on the lower reaches of the streams and who may use the water of these streams for drinking purposes. Under no conditions should a privy be built over a stream. In the light of our present knowledge of typhoid carriers a privy so constructed is a sanitary crime. The water-closets and urinals in city and suburban parks are generally and should always be of the water-carriage type. The proper closet for a picnic grove is a dry, water-tight cemented pit covered by a carefully constructed privy, with a ventilating shaft of not less than eight inches in diameter, extending from the pit, on the outside of the house, to at least several feet above the roof; the seat should be provided with a lid so as to exclude flies, and the whole arrangement should be properly screened by bushes or a trellis of vines, in order to insure the necessary privacy. The contents of the closet can be disposed of on some near-by field and composited by covering with earth, or it may be directly plowed under for fertilizer; but such material should not be put upon land where it is likely to be washed into streams.

The urinals in rural parks and groves are generally filthy and highly odoriferous. Wooden and cement troughs soon become saturated and offensive and glazed porcelain is not practicable in the woods. Dr. Poore, the English authority on rural sanitation, recommends the dry system of urine dis-

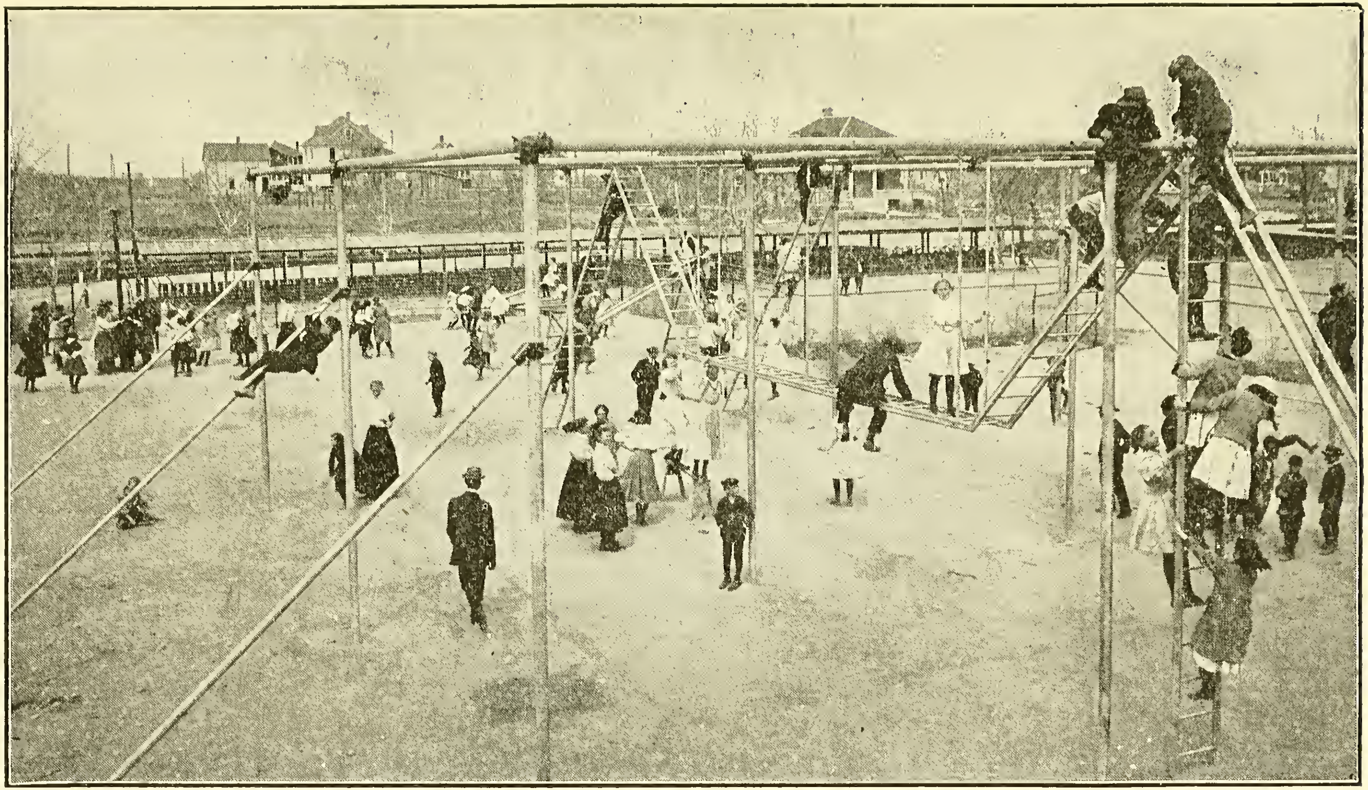


Fig. 28.—A Model Playground.
These playgrounds are equipped with the most modern apparatus. Instructors are present to guide the play instinct in healthful channels. (*Courtesy Playground and Recreation Association.*)

posal. The method consists in simply making use of the nitrifying properties of the soil. Over a space about two feet wide and six or eight feet long, depending on the needs of the grove, the soil is turned up with a spade as in digging a garden bed, and into this trench the urine is received; and here it is quickly and inoffensively destroyed by aeration and the nitrifying germs which are present everywhere in the upper soil layers. Ashes, sawdust, peat, or even lime may be mixed with the soil in the trench, but it is hardly necessary if the soil is at all loose and absorbent. If the place is much visited the soil should be turned up with a shovel or hoe every week or two. The urinal should adjoin the privy, be open on top to let in sunlight, and divided into suitable compartments; but care should be taken in the construction to arrange the woodwork so that it does not become liable to saturation with urine. Promiscuous urination on the grounds should be prohibited, especially near a stream. To this end "Commit No Nuisance" signs should be posted in all likely places. (Bashore. "The Sanitation of Recreation Camps and Parks.")

The sanitary care of parks and groves should be under official supervision. These duties may be entrusted to the park police, after receiving suitable instruction.

Garbage and other waste from fruit stands, eating places, etc., and everything of a putrescible nature should be buried or burned.

The exposure of food for sale at stands and booths is a distinct danger. Food so exposed to public view should be protected from flies, dust, and accidental expectoration by screen or preferably glass covers.

The dust nuisance and danger should be controlled by sprinkling or oiling the roads.

The water supply of city and suburban parks is generally from the city mains, while that of rural groves and pleasure parks must necessarily come from streams, wells or springs.

Many pleasure parks, situated on wild and uninhabited uplands at the fountain-heads of the lowland streams, still furnish good drinking water, and in very few instances has trouble been traced to this source; but with increasing population, and the same amount of carelessness as we have been accustomed to in the past, it will not always remain so. The proprietors of parks should be held accountable for the kind of water furnished their patrons. (Bashore.)

Public playgrounds for children are a desirable feature of city life. They vary from the vacant lot equipped with a few swings to the pretentious grounds in the public parks containing gymnastic apparatus of various sorts, sand beds, wading pools, etc. There is a commendable tendency to utilize the grounds of the public schools as public playgrounds for children. It is needless to say that play and recreation under these conditions is more healthful than time spent in the dirty and dangerous city streets.

Some cities located on the sea, lakes, and large rivers are now providing recreation piers on which the people may escape from the dust-laden air of the city. They are a Godsend to mothers of small children, especially on hot summer nights. These piers are part of the park system; some adjoin the large parks, others are located on the water front of the slums, where they serve their most useful purpose. Kindergarten classes are conducted on the municipal piers of New York City, and free band concerts are held on them throughout the warm season.

Chapter XIV

RURAL SANITATION

Rural Housing. The impression prevails that the mere fact of living in the country places one under favorable hygienic conditions. Such is far from being the case, for sanitarians are now calling attention to the fact that the death-rate is falling more rapidly in the cities than in the rural districts, the cause of which is simply a matter of sanitation. Filth due to neglect and disregard of sanitary precautions exists in rural not less than in urban districts. We are accustomed to think of the pure country air, nevertheless the atmosphere in villages and in the vicinity of farmhouses is frequently contaminated by the improper disposal of wastes from the household and the barn. It is hard to believe that overcrowding exists in the country districts, but the more the subject is studied, the more the fact becomes apparent. There are conditions in our own small towns and villages almost as bad as were formerly seen on the East Side of New York. They are bad enough in a typical farming community inhabited by native-born Americans, but they are vastly worse in the great mining and manufacturing districts, peopled largely by foreigners from Central and Southern Europe.

In many villages and small towns, especially those which are on the "boom" from some rapidly increasing industry, the land is overcrowded with buildings, much of which is due to the "row." Building in rows may be necessary in great cities, but it is certainly unnecessary in villages and small towns. Houses built in this manner lack air and sunshine in some of the rooms, and this leads to overcrowding of those that are better lighted and ventilated. Village streets are seldom as wide as city streets, yet adjoining these narrow streets as much land is covered relatively by buildings as in the city. Village houses are not as high as city houses, but the real condition as regards air is frequently worse than in the city, for the narrow street is usually lined on both sides with low, bushy trees, and the houses on account of the lack of height, have such low ceilings that there is really less circulation of air than in the ordinary city home.

House or room overcrowding is the common housing defect met with in the country—sometimes owing to the ill-constructed building, poverty, or thoughtless landlord, but in many instances to the carelessness and shiftlessness of the people themselves. On the other hand, there is much overcrowding by the families of well-to-do farmers living in large houses, but occupying only one or two bedrooms from a mistaken idea of economy in fuel. Another phase of overcrowding in the country, just as in the city, is the "lodger evil," especially in those districts that are rapidly developing. In some mining towns it is not unusual to find four to eight adults living in one room.

Defective building is the cause of a great deal of the bad housing conditions in the country. The houses are rarely planned by architects; the country carpenter, ignorant of the first principles of building construction, does the work, and the result is that many country houses have gross sanitary defects. Some of these faulty conditions are brought about by the remodeling of old buildings without the supervision of an architect.

The chief sanitary defects found in rural buildings are small windows and lack of windows. Many instances occur of houses—isolated and open on all sides—in which one small window is the only opening on the side of the house.

The damp cellar is another prominent defect in rural building. A damp, musty odor is characteristic of country houses, and dampness predisposes to rheumatism, which is common in many rural districts. No building should be built over a cellar which is not damp-proof.

Most of the defects in rural housing would be corrected by building every house with open space all around it, an ample number of large windows on every side, and by the elimination of damp cellars.

Lack of efficiency, disease, and premature death to many are the result of this overcrowding and lack of proper housing in the country just the same as in the large cities. Statistics seem to show that tuberculosis, the great disease of the overcrowded, is as prevalent in the country as in the city. Ignorance and habits of carelessness maintain the infection in the farmhouse and in the mountain home. Sanitarians now speak of "lung houses" in the country as they do of "lung blocks" in the city. The country slum is the analogue of the city slum and, like it, is a focus of infection of the communicable diseases.

In the city the public authorities supply the householder with water for domestic purposes, and remove the sewage, garbage, and ashes from his habitation; therefore he may restrict his attention, so far as his dwelling is concerned, to the purity of the supply of air, e. g., to heating, ventilation, and plumbing. In the country his care must be devoted principally to the sources of drinking water and to the means of removing and disposing of the waste matters from the house and barn.

As a country becomes more thickly settled, rural sanitation increases in importance. When the population is scattered the soil and the water courses are not intensively polluted, and man is protected by his isolation. As population becomes more dense it becomes necessary to advise communities in regard to the prevention of disease and to enforce rules for the conservation of the public health.

Water Supply. Water for domestic use in the rural districts is generally derived from the following sources: shallow dug (surface) wells, springs, rain water, rivers, ponds, or artesian wells.

Shallow Dug Wells. The surface well is the most common source, and it is ordinarily badly situated and almost always polluted. It is not infrequently placed at a much lower level than the privy or the stable, and receives the drainage from both. It is sometimes located in the barnyard. Pumps and not buckets should be used to raise the water, as open wells are collecting places for wind-borne filth and dirt and sometimes for wash water. In India and the Philippines the well bucket is a factor in the dissemination of cholera and in this country of typhoid fever. The water-tight cover of the well should have sufficient pitch to throw off all rain water. The pump must be provided with a gutter to carry off the waste water. Special precaution must be taken to keep the joint at the foot of the pump water tight. The cover or platform may be made either of matched boards or of heavy timbers calked with oakum and tar; or, better still, it may be of concrete or cast iron. Any water-tight construction substantial enough to stand the weather and the weight put upon it will suffice. The curb may be of brick or masonry laid in cement mortar or it may be of concrete, and should extend at least 2 feet into the ground and rise at least 1 foot above the surface. The earth should be banked up around it so that surface water will be shed promptly. The casing or lining of the well may be of brick or stone laid in cement, of reënforced concrete or terra-cotta sewer pipe with cemented joints. It must be absolutely water tight down to the level of the ground water.

The location of the well is of the greatest importance. It should be placed above any source of pollution (privies, pigpens, stables, etc.) and as far from it as possible. If the water is pumped to a tank and piped to the house and outbuildings, the well should be located in an open field 100 yards or more from the dwelling, stable, or privy; if not, the area occupied by the well should be inclosed and the precautions for preventing surface pollution rigidly carried out. The ground about the well should be kept scrupulously clean. If a bucket is used, it should be inclosed in a windlass box and provided with an automatic device for emptying the bucket through a spout so that it need not be touched with the hands. ("Sanitation of Rural Workmen's Areas," issued by the Council of National Defense.)

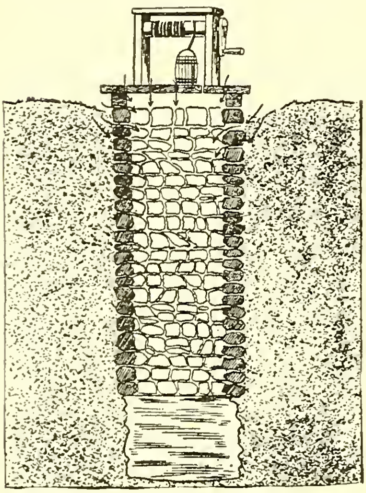


Fig. 29.—Showing the Construction of a Bad Type of Well. (*Virginia Health Bulletin.*)

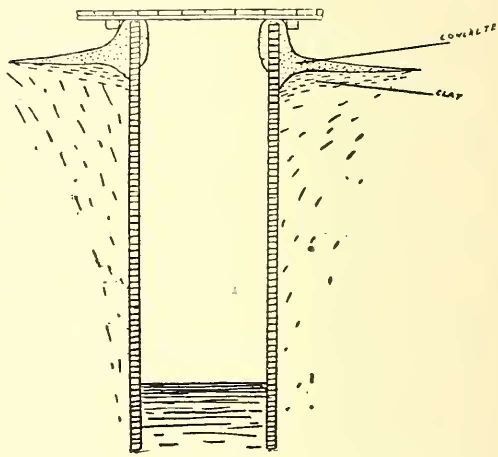


Fig. 30.—Showing the Construction of a Good Type of Well. (*Virginia Health Bulletin.*)

Springs. Springs are a common source of domestic water supply, especially in hilly or mountainous country. The water is generally pure as it issues from the ground, but it may be polluted by seepage of polluted water through the soil above, by direct washing of surface water into the spring, or by dipping dirty vessels into the spring. It is protected against seepage by locating the privy or stable elsewhere than on the slope above the spring. As a protection against surface washing a ditch should be dug on the slope above the spring to lead the surface water around it and into the spring branch a safe distance below. This ditch should be as close above the spring as practicable, but should be deep and wide, with the dirt banked on the downhill side.

The danger of surface pollution may be entirely prevented by inclosing the spring in a brick, masonry, or concrete box provided with a pipe inserted in the side for the overflow of the water. Under the end of this pipe a bench or platform should be built on which to set the bucket while it is filling with water, thus rendering it unnecessary to dip vessels into the spring.

Rain Water. Probably the safest supply for rural districts is rain water, provided the rainfall is sufficient. Its collection and storage are discussed in the chapter on "General Prophylaxis."

Surface Waters (Rivers, Lakes, Ponds). All surface waters should be considered as polluted unless their purity has been established by careful chemical and bacteriological examination, and by a careful inspection of the watershed from which the water is derived. Water from rivers, lakes, and ponds is usually stored in reservoirs, in which it undergoes a measure of purification before being used. Reservoirs are not practicable for small communities because of their cost, but by combining resources the residents of a thickly populated rural district should be able to provide such a system. In many instances pure water cannot be obtained without the use of a filter bed.

In communities having a general water supply every floor of the habitations should, of course, be provided with water taps.

Artesian Wells. Pure water is usually furnished from artesian wells, but much depends upon the geological formation of the district. In limestone regions the wells are liable to tap waters that come from polluted sources without the filtration which usually takes place as water passes through the soil. There are many formations from which it is impossible to obtain water. The depth of the well is no indication of its purity. The use of artesian wells is advisable where it is possible to have them at a cost that is not greater than that of pure water from other soures. (Brewer.)

Ice Ponds. The pollution of ice ponds should be prohibited. The Massachusetts State Board of Health requires a careful inspection of the watersheds of ice ponds, and grants permits to cut ice only after approval in specific cases. This protects the public health, for though the danger of disease transmission by infected ice is small, it nevertheless exists. Snow ice and the first inch of clear ice should be rejected, as the surface may become contaminated after freezing. Recently frozen ice is the most dangerous. The danger is reduced by harvesting ice that has been frozen for some time or by storing it for some months before use.

The Collection and Disposal of Excreta. Isolated country dwellings and farmhouses usually derive their water supply from wells, springs, or cisterns, therefore it is of the utmost importance to keep the water pure and to prevent any possible contamination, either directly or by soil pollution. This involves the elimination of such sanitary anachronisms as the leaching cesspool and the insanitary privy vault. Aside from the danger of water contamination, soil pollution is in itself a menace to the public health, especially in warm countries like the southern United States, where hookworm disease is prevalent. The danger of the transmission of infection by flies from fecal matter to food is greater in the South, as the warm season is longer, hence more care must be exercised in the collection and disposal of excreta than in colder climates.

Some villages, summer resorts, institutions outside the city limits, and many country estates, have their own water services, in which cases the water-carriage system of sewage disposal is generally utilized. The purification and ultimate disposal of the sewage depends upon local conditions and is discussed in the chapter on "Municipal Hygiene." Many of the systems in use involve treatment of the sewage in septic tanks.

"Many summer hotels and large farm boarding houses, located on the shores of lakes or on the banks of streams, pollute these water courses by discharging a large volume of sewage into them. They thus form a menace to the health of the people further downstream who may use the water for their water supply. Hence the arrangements for the disposal of the sewage of summer resorts should be rigidly inspected annually by the health authorities, and offenders in the matter of stream pollution should be punished. The entire sanitary conditions of such places often require a very careful and strict inspection, and no nuisances of any kind should be tolerated." (Gerhard.)

The disposal of excreta in temporary and permanent construction, lumber, and pleasure camps should be governed by the same principles that guide military sanitarians in the sanitation of army camps. These are discussed in detail in the chapter on "Military Sanitation."

Dry Earth System. In this system the water-closets of the water carriage system are replaced by removable watertight receptacles such as pails, tubs, cans, or pots, in which the fecal matter is kept covered with dry earth, ashes or lime. Each person covers his stool as soon as passed. The receptacles should be changed daily, and a clean, empty one substituted. The feces are usually buried. The system will fail unless cleanliness is maintained by users and collectors, the collections made regularly and often, the material protected against flies, and promptly buried in proper soil, and the receptacles occasionally disinfected. It is frequently the only possible *sanitary* method for houses situated near streams or lakes used for public water supplies, for isolated houses, for temporary construction camps, and for small scattered summer colonies.

THE SANITARY PRIVY. This subject is of the greatest importance in rural sanitation, and it is only during the past ten years that it has received the serious scientific study that it deserves. The greatest advances are due to the efforts of Professor Charles W. Stiles, U. S. P. H. S., and other officers of the United States Public Health Service, in conjunction with their investigations of soil pollution by the hookworm in the Southern States. The following paragraphs are abstracted largely from the reports of their work in the Public Health Reports of the Public Health Service and from reprint No. 487, entitled "Sanitation of Rural Workmen's Areas" in the same series.

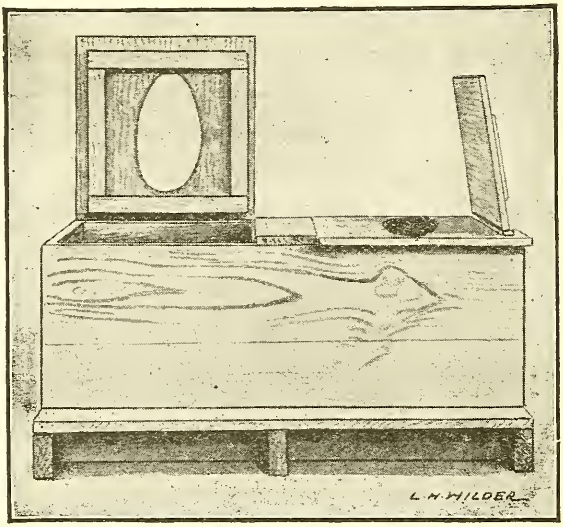


FIG. 31.—FRONT VIEW OF TWO-CAN BOX WITH TWO ADJUSTABLE COVERS. (*Public Health Bulletin, No.* 89.)

Sanitary privies are especially applicable in rural districts, but are sometimes used in communities for economic reasons, on account of the severity of the winters, or where a proper grade or a sufficient water supply cannot be obtained for the removal of excreta by sewers. Pit privies, where the privy house is built over a hole dug in the ground and is moved to a new position after the pit is filled, cannot be classed as sanitary, because of the danger of pollution of underground water, and the use of such privies is condemned. Worse still is the method of polluting the water supplies by placing privies directly over the water courses. The only kinds of privies which may be classed as sanitary are those with either removable receptacles (box privy, pail system, incinerating system, etc.) or stationary receptacles from which the excreta or an effluent are to be removed. The box privy and pail system embody the principle of the earth closet. In ordinary habitations there should be at least one privy seat for every ten persons or less.

Removable-receptacle Privies. There are several satisfactory types of these privies. The covered can type consists of a stout water-tight can fitted with a wooden top having a suitable hole in it to serve as the seat. The hole in the seat is covered with a hinged lid. The seat board is closely fitted to the top of the can and the lid fits closely over the hole. To provide ventilation, the lid may be a framed screen.

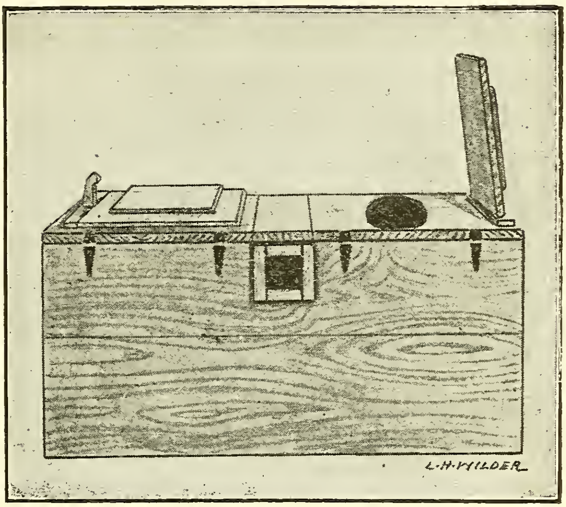


FIG. 32.—BACK VIEW OF TWO-CAN ADJUSTABLE COVER BOX. (*Public Health Bulletin, No.* 89.)

The boxed-can type consists of a suitable water-tight receptacle, incased in a box which serves as a seat. The receptacle may be can, pot, or other water-tight vessel. For purposes of ventilation and easy removal, it is advantageous to have a space of about 2 inches between the top of the receptacle and the under surface of the seat and between the sides of the receptacle and the sides of the box. The box must be fly-tight and substantially built. The lid should be hinged at the back or to one side of the hole. It should be arranged to drop into place of its own weight when the privy is not in use. The top or front of the box should be hinged to permit removal of the receptacle for cleaning. Such a commode may be placed in a privy house or in any other suitable building,

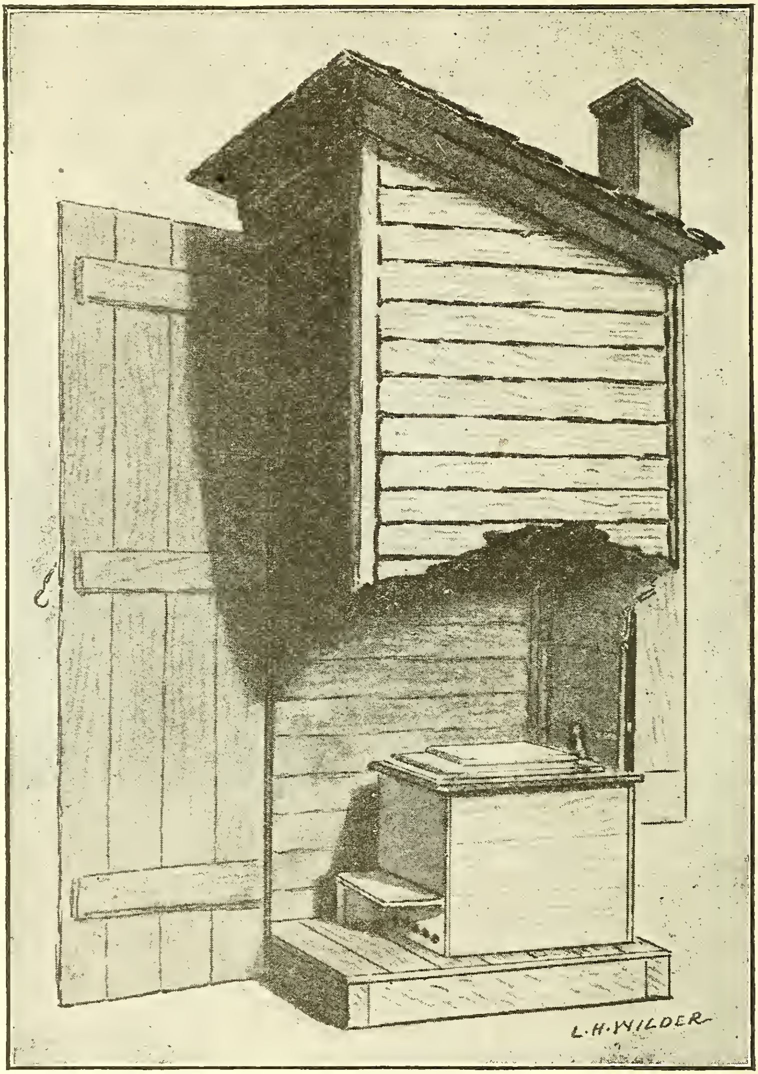


Fig. 33.—One-can Adjustable-Cover and Vent-Flue Installed in Privy. (*Public Health Bulletin, No.* 89.)

such as a barn or woodshed, and is thoroughly practicable for use.

In one of the sanitary privies designed by Stiles the boxed receptacle is made part of the structure of the privy house, the back and sides of the house serving as parts of the box. The general use of such privies in towns not supplied with sewage systems and in the country would reduce the morbidity from typhoid fever, hookworm, and other fecal-borne diseases.

The box should be well ventilated to remove objectionable odors. This may be done by means of screened openings in the seat cover and the sides of the box, or better still, by a ventilating flue from the box to the outside. The flue may be made of boards, or a triangular flue may be made by nailing a board upright in the angle formed by one side and the back of the privy house. The opening of the flue in the box should be screened against flies. As a further means of preventing markedly disagreeable odors from the privy contents, as well as making the matter safe and less disagreeable for removal and final disposal, the use of drying powders, such as lime, dry earth, and ashes, or a disinfectant such as crude carbolic acid, 5 per cent., or the compound solution of cresol, 1-19, is approved. Another method is to pour into the tub about 2 or 3 inches of water; this plan gives the excreta a chance to liquefy as in the septic tank. A cup of coal oil should be poured on the water to repel insects.

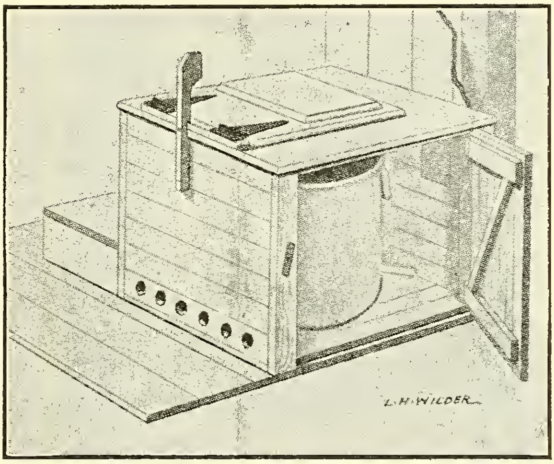


Fig. 34.—The One-Can Fixed-Cover Box with Back Door for Removal of Can and End to End Ventilation.

The air inlets are at the left end of the box and the vent-flue extends from the right-end of the box, through and up the side wall of the privy with outlet as indicated in Fig. 33. (*Public Health Bulletin, No.* 89.)

Earth closets are made in which dried and sifted earth is retained in a hopper above and about $1\frac{1}{2}$ pounds falls on the excreta when the plug is pulled up. This is sufficient to remove all smell and form a compost which is inoffensive as long as it remains dry. It is removed periodically and may be stored under a fly-proof cover until it can be used as a fertilizer and promptly plowed under the soil. Such compost should never be used as superficial fertilizer. For large camps strong boxes lined with sheet iron and long enough for six seats can be placed on low trucks and hauled directly to the fields.

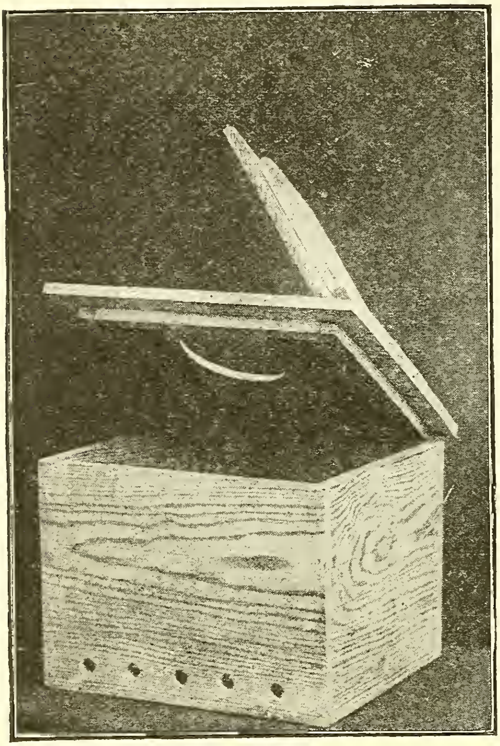


Fig. 35.—Privy Box of One-Can Adjustable Cover Type.

Showing certain details of construction. (*Public Health Bulletin, No.* 89.)

If the privy is installed on an alley in a village or town and is to be cleaned by a public scavenger, the box should be arranged to open in the back of the privy, so that it may be cleaned from the alley. In such a case, it is also advisable to have the receptacles of the same size, so that the scavenger may replace the full cans with empty cans and take the former, after covers have been placed securely upon them, to the point of disposal.

Stationary-receptacle Privies. If the receptacle does not have to be removed from the privy for emptying, it may be of large capacity, and thus the frequency of disposal of contents may be lessened. The receptacle may be of wood, iron, or concrete. Concrete is the most durable and, in the long run, the cheapest. The vault must be water-tight. Preferably it should be built wholly or partly below ground to prevent freezing. The water-closets may drain directly into it, or else by means of soil pipes and drains. The same principles of fly-proofing, ventilation, and the use of drying powders and disinfectants apply to this as to the removable-receptacle privy. The construction should be such that the excreta will be accessible for safe and cleanly removal. Even if these precautions are taken the vault system can be regarded as only fairly satisfactory.

The principles of the septic tank are applied in the L.R.S. (Lumsden, Roberts, Stiles) privy, which consists of the following parts:

(1) A water-tight tank, barrel, or other container (preferably of iron or concrete) to receive and liquefy the excreta.

(2) A covered water-tight can, pot, barrel, or other container to receive the effluent or outflow.

(3) A connecting pipe about 2½ inches in diameter, about 12 inches long, and provided with an open **T** at one end, both openings of the **T** being covered with wire screens.

(4) A tight box, preferably zinc lined, which fits tightly on the top of the liquefying barrel. It is provided with an opening on top for the seat, which has an automatically closing lid.

(5) An antisplashing device, consisting of a small board placed horizontally under the seat about an inch below the level of the transverse connecting pipe. It is held in place by a rod, which passes through a hole in the side of the seat and by which the board is raised and lowered. A layer of chips floated in the tank may be used instead of this device.

(6) A ventilating pipe, such as a stovepipe or wooden flue, connecting the space under the seat with the open air.

The liquefying tank is filled with water up to the point where it begins to trickle into the effluent tank. A pound or two of old manure should be added to the water to start fermentation. As an insect repellant a film of some form of petroleum may be kept on the surface of the liquid in each container. Water must be added to the liquefying tank from time to time, to prevent the matter from becoming too thick. Disinfectants must not be used in the liquefying tank, because they stop fermentation; but they may be used to good advantage in the effluent tank. The effluent is to be regarded as potentially dangerous, and must be disposed of accordingly.

The final disposal of privy contents varies with the type and method of operation of the privy. Privy contents may be disposed of (1) by burning, (2) by discharge into a sewer, (3) by burial, either with or without disinfection by heat or chemicals.

Collection and Disposal of Garbage and Other Refuse. Every household should be provided with galvanized-iron, water-tight garbage cans, with tightly fitting lids to keep out flies and vermin. Other cans should be provided for ashes and sweepings. Where the refuse is to be incinerated it may be collected in a single can. In rural districts garbage is generally fed to swine and poultry, in which case it should be free from broken glass and other injurious foreign matter. Garbage and other refuse may also be used as a fertilizer or as fuel. In the latter case, in order to obviate offensive odors and enhance its fuel value, garbage should first be strained for the removal of liquids and then placed for drying in a perforated receptacle in a hot-air chamber which has been devised in connection with the lower part of the kitchen stovepipe. Garbage may be thrown in shallow layers into a trench, dug for this purpose, and covered with earth. Dry refuse, such as sweepings, may be best disposed of by direct burning in the stove.

Where there is no demand by farmers for garbage or manure these wastes may be destroyed in special incinerators such as are described in the chapter on "Military Sanitation." A suitable place should be provided for the disposal of ashes, cinders, and street sweepings. Such material may be utilized in filling up swamps and overflowed lands, but this made land should not be used for building sites.

Control of Rats, Flies and Other Vermin. The rat-proofing of houses, barns, granaries, etc., as described in the chapter on "General Prophylaxis" is highly desirable, both for sanitary and economic reasons, and especially should be employed in communities along the seaboard, on account of the possible introduction of bubonic plague at such ports. The rat-proofing of buildings not only prevents rats but also tends to prevent other vermin. For the latter purpose the interior of buildings require extra attention. Care should be taken in the selection of materials for interior finishing, not only to obviate the breeding places of vermin, but to facilitate regular mechanical cleansing and fumigation. The use of oil dressing regularly after scrubbing wooden floors and walls not only keeps out vermin but preserves the wood.

The fly nuisance must be minimized by the proper care and disposal of manure and other organic wastes, the screening of houses and the protection of food. Fleas, bedbugs, and roaches must be controlled by cleanliness and the use of insect powders. Lice are controlled by the practice of hygienic personal habits. In rural districts special attention should be given to the elimination of the breeding places of mosquitoes, particularly the malaria-carrying mosquitoes.

General Cleanliness. It is frequently observed that the same standard of cleanliness of person and surroundings is not maintained by persons of the same walks of life in the country and in the city. As a rule baths are not so easy to obtain in the country, as the water supply is not so plentiful; the disposal of waste matters in the country is far from perfect except under the most favorable conditions; in rural communities people are apt to live in more intimate association with live-stock and household pets, and many a well-bred city dweller has been shocked to find bedbugs in the bed of his country cousin. Some of these conditions can and will be improved as knowledge of personal hygiene becomes more general and people come to appreciate the importance of biological cleanliness; others are more or less inseparably associated with agricultural life, and no improvement can be hoped for in the immediate future.

Chapter XV

SCHOOL SANITATION

Schoolhouses. The problem of providing the rising generation with hygienic and sanitary surroundings is one of great importance and difficulty. The compulsory attendance for all children up to a certain age in most states has made the state responsible not alone for their mental welfare and training, but for their physical welfare. The state is therefore bound to establish as high an ideal of sanitation as possible, not alone for the protection and promotion of the health of the children, but as a sanitary example to the public, which now looks to the schools and their administration for its sanitary standards. Hygienic and sanitary knowledge and ideas acquired by the children in the public schools are transmitted by them to their families, especially in the poorer quarters of large cities and in backward rural districts. The benefit derived from this is soon apparent in the improved conditions noted in their homes. Decent toilets and washing facilities are installed, houses are screened, efforts are made to keep the family free from vermin, etc.

The sanitary standards for schools have not as yet been stabilized, but much improvement has been effected in recent years. This has been largely due to the competition of school engineers, architects, and supply houses, who are stimulated by the large pecuniary rewards in this line. The following are the tentative school sanitation standards for city public schools given by Professor L. W. Rapeer in his valuable work, "Educational Hygiene."

The Site. The site should be on rather elevated, porous, uncontaminated soil, preferably gravel and sand. This tends to obviate muddy, wet feet and clothing and foul air rising through the basement from a contaminated soil.

Size. Thirty square feet of play space is the minimum established by the National Playground Association of America as a standard. One hundred square feet is specified by the London School Board. Allowance must be made for future extensions of the building and for any parking space absolutely required. A full city block is a convenient minimum standard. Where blocks are as small as 200 feet square, two for each school will frequently be standard. Ten to twenty acres of good land should be made available for consolidated rural schools, two to three acres for school and neighborhood playgrounds.

Surroundings. The school building should be in a quiet place, free from dust, bad odors, and gases, overshadowing buildings, and away from sources of ill health or injury to pupils. This standard has been overlooked or neglected in locating many American schools, which are not infrequently built on street-car, automobile, heavy-traffic, and even steam-railway streets or lines, or near dusty roads or factories, gas-houses, livery stables, planing mills, and saloons. Foresight must be used and the law invoked to protect schools from such dangers to life, nerves, health, and sanitation.

The Building. The building should be arranged longitudinally, so that classrooms may have unilateral east or west lighting, the children in the rooms on the west side of the building (if of several rooms) facing north and those in rooms on the east facing south.

If possible, the building should be placed at the west side of the school site, with the separate heating plant to the west of the building. This puts almost the entire playground in front of the school building, where it can be supervised to some extent from the principal's office, which should preferably be located in the front in the middle of the second floor.

The rear of the building to the west, with its separate heating plant and smokestack, should be made as attractive as possible, so the building will not have to "turn its back" on any neighborhood.

Practically every school should have a well-lighted concrete basement. In smaller schools the heating plant will be located here. Great care should be taken to prevent the upward movement of moisture in the walls to the school walls above. Slate, pitch, and other substances are used to cut off this upward movement.

Arched roofs and steeples are rapidly giving away to flat roofs, and very low towers, if any, on the larger school buildings of four or more rooms. Roof playgrounds should be provided where needed.

Every school building should be as nearly fireproof as possible, and the larger the building the more emphasis should be placed on this factor.

The building should be as nearly free from dust-catchers as possible. All interior woodwork should be without unnecessary flutes and grooves. Fluted or beaded ceilings or wainscoting, and much decorated washboards and blackboard frames, are inadmissible. Picture moldings are recommended, but they should so be devised as to catch little dust.

Corridors may have a standard width of 14 feet in schools of several rooms. All corridors should be well lighted, should have cement or light-colored composition floors, should be unencumbered with lockers or wardrobes, and should be provided with satisfactory drinking fountains, preferably in "batteries" of four or more over a narrow trough close to the wall. The latter need not be as elaborate and costly as are frequently purchased.

All other flooring should be sound-proofed and made of close-grained hardwood or of rift-sawed pine. As soon as laid, the floor should receive two coats, well rubbed in, of *boiling* linseed oil, in which one pound of paraffin to each gallon of oil has been dissolved. This coating closes up and protects the wood and provides a vitreous-like surface easily cleaned and hard to splinter.

The Classroom. The classroom is the center of the school. Here teacher and pupils engage for most of the time in that activity for which schools are primarily created. The sanitation of the classroom should therefore be as perfect as possible.

Each school building contains one or more standard classrooms. The classroom should be the unit of construction. Instead of planning a building of a certain size and then putting in classrooms, architects should reverse the process and provide the required number of standard classrooms and erect the building around them.

Size. The best size for an elementary classroom for about forty pupils seems to be, all matters considered: length 32 feet, height 13 feet, width 24 feet. This size has in consideration sufficient lighting space, the carrying power of voices, distance for seeing and hearing, ease of class management and instruction, ventilation, building economy, etc. The height may be reduced 6 inches and the length a foot or more, if desired. In high schools the height should be the same, but the floor area and shape must be variable.

Lighting. In standard classrooms the lighting, measured in area of window-glass, should be at least one-fifth to one-fourth of the area of the floor space. The lighting should, as a rule, be from the left side only of the pupils seated. Windows should reach to within 5 or 6 inches of the ceiling—the higher the better, since about one-third of the light comes in at the upper fourth of the windows. The windows, on the 13-foot wall, should not reach below a line 3½ feet above the floor; should extend as far toward the rear of the room as possible (within 18 inches); should not extend far enough forward to throw much light into pupils' eyes; and should have the narrowest possible piers or mullions between the windows, say

1 foot as a maximum, and the piers should be beveled. Round or gothic-topped windows should not be permitted. In upper grades, the height from the floor may be 4 feet. The width of the glass panes may well be about 42 inches and height 45 inches. Small panes are generally less desirable. It is injurious to the eyes to face windows, both for teachers and pupils; consequently there should be no windows on the front wall, and on the rear wall only when it is thought desirable for ventilation.

All classrooms should have artificial lighting for use on very dark days and especially for evening use. If possible electricity should always be used, and all buildings should be well wired when constructed. Gas-pipes should also be installed where gas is available. Acetylene lighting has been found satisfactory where the other forms are unavailable.

Light-green or light-gray window shades may be used to harmonize with wall colors. Dark green should be avoided. The ideal is to get plenty of light without cutting off too much and without allowing the direct rays of the sun to fall on the pupils' work.

All walls should be smooth but not glossy, and painted with washable flat paint in light tans, light greens, light buffs, or light grays. A cement dado should take the place of the ordinary wooden wainscoting, and may be painted a darker color than the walls above. The ceiling may be nearly white in color. Great differences in light can be made by giving care to wall colors. In corridors more white can be used without injury to pupils' eyes, and white tiling for the first 4 or 5 feet above the floor is desirable.

Heating. The proper temperature for classrooms in this country is from 65° to 68°. Rooms should be allowed to go above 70° only on cold mornings while the building is being heated up. The air should be about half saturated with moisture, say 55 per cent. No general standard can be established for a country as large as this and for schools of all sizes. Hot-air furnaces for small schools of two to six rooms are in some cases desirable, especially in places where there are mild winters. Hot-water heating has many advantages, but is slow, and not so desirable for the more northern schools, perhaps. Steam heating is growing in favor in all the larger schools. It works well with a fan (plenum or exhaust or both), system of ventilation. When the air entering the rooms is slightly heated and the air heated indirectly by radiators also we have the "direct-indirect" method which is a very common and very desirable method of heating schools.

Ventilation. Standards of school ventilation are at the present time disturbed by two movements. The open-air-school movement has brought a great emphasis on obtaining outdoor conditions without great discomfort, and a widespread discontent with current methods of ventilation. Secondly, scientific studies and experiments of recent years have fairly well proved that it is not the lack of oxygen, or the excess of carbon dioxide or of organic particles that makes schoolroom air unfit to breathe, but it is improper temperature, lack of variation in temperature and movement of the air, and lack of humidity that cause the bad effects. These two beliefs have led to two principal applications: furnish less heat and convert classrooms into *fresh or open-air* rooms, and second, convert classrooms into *closed-air* rooms, and by the use of return ducts and careful air-washing and humidifying return all air to the classroom, thus making it recirculate over and over again.

Not counting the initial cost of any changes in windows or the purchase of bags for the children to sit in in cold weather, the open-air room is evidently more economical than the fan system, saving very much in the way of coal. Likewise, overlooking the cost of return ducts, air-washers, and the closing up of cracks, the re-circulation of air for given periods of time is very much more economical than the present systems, which heat a volume of air and then force it out almost immediately in the effort to get proper ventilation. The matter is still in the experimental stage, and there is a possibility that a system may be developed whereby the open-air method may be employed in warm weather and the re-circulation device in cold weather.

Three common methods of ventilation are in vogue—*window* ventilation, *gravity* ventilation, and *mechanical* ventilation. Most American schools are supposed to use the first method, but the results are most indifferent. They have in the past been provided with as little means of proper ventilation as most homes, but the conditions are entirely different, especially in the great number of persons from different families that are here collected together to remain relatively fixed in stationary seats. Teachers must be trained and study along the lines of ventilation needs and devices.

Window Methods. Windows should be opened and the rooms flushed out with outdoor air at all recesses and intermissions. Teachers and pupils need not be afraid of fresh air in classrooms. By keeping on more clothing than in a 70° atmosphere they can easily and quickly accustom themselves to almost outdoor conditions even in cold weather. They are usually benefited by it, frequently becoming fresh-air enthusiasts. Draughts should be avoided when they strike directly on pupils. *Window boards* 6 inches in width and the width of the window in length may be placed beneath the window in such a way as completely to close up the space at the bottom of the window, but leave a space between the sashes in the middle of the window where the air will come in when it is colder outside than inside, without a draught on any pupil.

Gravity Systems. Differences in the weight of warm and cold air make what are known as gravity systems possible in cold weather—when windows cannot well be opened without draughts and heat-expense. They are generally not efficient enough for schools except in the coldest weather, but must be used in all small schools where forced, mechanical draughts are out of the question because of the expense. The jacketed stove is a gravity system. Heat within the jacket and heat in the chimney about the aspirating or outlet duct for foul air cause the air to rise and spread in the room and to be forced out by the colder air coming from without through a flue passing under the floor to a vent within the jacket of the stove. Care must be taken to insure that the fresh air brought in is not from under the building, and that the opening to the outside is covered with a screen.

The hot-air furnace is also a gravity system. The furnace is usually placed beneath the floor in the basement and has a flue bringing in outside air and other flues or pipes taking the air up to the rooms. The fresh air coming from the furnace should enter the room on an inside wall if possible and about 8 feet from the floor.

Mechanical Systems of Ventilation. This plan does not depend upon gravity alone, but puts a fan into the system to force air into the rooms—the plenum system; and frequently adds to this, in large buildings, another fan near the top of the building to blow the air out—the vacuum or exhaust system. When the upper fan is omitted, a feature of the gravity system is sometimes added in the form of small steam coils in the air flues to heat the outgoing air and make it rise faster. Generally the plenum fan or blower in the basement is sufficient.

Accepted standards for such ventilation require at least 30 cubic feet of air for each person in the room per minute. The air should enter the room at a height of 8 feet above the floor through a vent about 2 feet square. If a grating is placed over this inlet it should be of such small cross-bars as not seriously to retard the air. It should also have deflectors attached to throw the air upward and toward all parts of the room. The speed of the entering air should not be more than 400 feet per minute as measured by the anemometer.

The ducts to each room of forty pupils should be at least 4 feet square in cross-section, so as to keep the velocity within them below 600 feet a minute. The entrance duct may be at the front of the room and the outlet duct (4 feet square in area) at the floor in the same wall, with another outlet 6 to 8 feet above the floor in the cloakroom behind the front wall of the classroom. The air can be made to reach the cloakroom by placing openings in the bottom of the doors leading from the classroom to the cloakroom. Such an arrangement helps to dry and aerate the clothing.

The fan or blower in the basement should be noiseless, and should be large enough to provide an ounce of pressure without running more than 300 revolutions per minute. The fresh air should be taken from a point where there is little dust or smoke, which in cities is usually high in the air above the roof. If the air is still dusty or smoky it should be washed before entering the rooms. Numerous devices for air washing have been devised, about the best at present providing for passing the air through a stream or "rain" of water dropping from small holes in a pipe across the passage. Such an arrangement, if properly put in, may provide sufficient humidity to the warmed air also. The standard for humidity is about 55 per cent saturation. It is doubtful if the air should ever be hotter than 65° F. in the fanroom of the basement, and very little warmer when it enters the rooms. The radiators are principally for heat. The air should be kept as cool as possible consistent with comfort. Provision should be made whereby the air may be diverted at times into the ducts without passing through the heat coils across the entrance to the fanroom, thus making it possible to get fresh outdoor air at physical training or other periods.

The air velocity of all rooms should be measured once or twice a year, or whenever a room seems to be getting too much or too little air. The velocity of the incoming air should be taken as the average of several measurements at several points on the 4-square-foot surface of the mouth of the duct. This average velocity for the whole area should be multiplied by the area in square feet to get the quantity entering for a given length of time, say thirty seconds. This product divided by the number of pupils and teachers in the room will give the average amount coming in for each person.

Blackboards. Blackboards should be of slate, although glass and composition boards are being perfected. In the standard classroom, blackboards will be placed on the rear, right, and front walls. They must be written on by both teacher and pupils and consequently should be wide enough to meet the needs of both. The front board may well be 5½ feet wide, and the others 4 feet or perhaps 3½ feet, to avoid as much light absorption as possible. In primary rooms the bottoms of the boards should be not higher than about 26 inches from the floor, and in upper grades and high school about 30 to 38 inches above the floor. The increase in height may be graded between these extremes. Hard, dustless chalk should be used, and wire hinged screens should cover chalk troughs. Curtains on rollers of a light color may be used to cover boards when not in use, in order to prevent light-absorption. Soft, dustless erasers should be used and should be cleaned once a week or oftener. The vacuum-cleaner makes this an easy matter.

Cloakrooms. Hanging the clothing and hats in the halls and corridors is undesirable. Each classroom should have one cloakroom, and it should open into both the classroom and the hall. It should be lighted from the outside, ventilated to carry off odors, and heated to dry the clothing. Drip-troughs should be provided for umbrellas Pigeonholes or other spaces should be provided for overshoes, and it is also desirable that each pupil should have a shelf on which to lay hats and other articles. The hooks upon which the clothing is hung should be far enough apart to keep the clothing from contact. This tends to prevent the dissemination of vermin. Hats should be kept separate for the same reason. Children should not be allowed to sit in wet shoes and stockings or in wet clothing. A drying chamber or at least a separate room for drying clothes is a desirable addition to a school. Dressing rooms with lockers should be provided for the teachers.

Drinking-water. A plentiful supply of clean drinking-water must be provided. The cold-water faucet should be equipped with the sanitary drinking-fountain. The common drinking-cup should not be tolerated.

Washing Facilities. The best of the modern sanitary schools have hot and cold running water in the classroom or the cloakroom. Drawing and other forms of school work require water, and some forms make the children dirty enough to require washing. When the basin is located in the cloakroom the floor may be made of the same composition as that of the corridors—cement, tile, asphalt, or composition. Paper towels and liquid soap from automatic containers should be provided.

General Cleanliness. Schoolhouses and their equipment should be kept absolutely clean. Cleanliness of person and surroundings is one of the most important things learned by children in school. They impart this knowledge to their parents with most beneficial results. Example and discipline are the best methods of instilling a love of order and neatness into the developing mind. Cleanliness of floors, desks, corridors, cloakrooms, toilet-rooms, basements, and grounds is absolutely essential. Blackboards should be frequently washed to avoid dust. Dry sweeping or dusting should be prohibited. Vacuum cleaning should be provided wherever possible. The floors should be treated with one of the dustless floor oils. The windows must be kept clean. Each pupil should have his individual pencils, books, and other equipment.

Waterclosets and Urinals. Separate toilets must be provided for boys and girls. The closets and urinals should be types that allow complete inspection and thorough cleansing.

The urinals should be constantly and automatically flushed. The ventilation of the toilet-rooms should be well planned. Separate exhaust fans for toilets in large buildings are necessary. Absolute cleanliness is imperative. The toilet rooms should be well lighted. There should be about one toilet seat for each fifteen girls and one for each twenty-five boys. One urinal should be provided for each thirty boys if the younger pupils are dismissed earlier than the older ones. Urinals should be made of slate or hard asphalt or other non-absorptive material.

The best modern practice is to have dry, well-lighted and ventilated basements for the large toilet-rooms and to have smaller ones of one stool each on each floor for each sex. Some of the best city schools have a toilet-room for each sex in connection with the classroom. This gives teachers better control, prevents the usual mixture of all children from all the rooms and in itself tends to decrease the opportunities for the dissemination of the communicable diseases by direct and indirect contact.

Medical Inspection of Schools. Systems of medical inspection have been established in many public schools and the idea is making steady progress. The experimental stage has been passed, and its necessity is now recognized by the thinking public, who appreciate the fact that a close relation exists between the physical and mental condition of the child during the entire course of its education. The object of medical inspection is primarily the prevention of diseases rather than their treatment. Two definite ends are sought: (1) The detection and exclusion of communicable diseases; (2) the general physical welfare of each child.

Medical inspection was started in American public schools with the hope of controlling the communicable diseases of children. This hope has been realized only to a limited extent. There has been only a slight decrease in the prevalence of diphtheria, scarlet fever, measles, mumps, whooping cough, and the other communicable diseases of childhood. Possibly increased interest in the subject and greater care in its administration may increase its efficiency.

Medical inspectors should be trained and competent physicians and sanitarians, and it is desirable that they should devote their entire time to this work. The assistance and advice of medical specialists, sanitary and heating and lighting engineers, and sanitary architects should be at their disposal. The duties of medical inspectors may be briefly summarized as follows: The early detection of the communicable diseases and the institution of measures to prevent their spread. They should personally report all cases to the health department, using a special form for that purpose. The supervision of vaccination and disinfection, the sanitation and cleanliness of the school building and its surroundings, the adjustment of the seats and desks, the medical supervision of the physical and mental work and welfare of the pupils. An important duty is the early recognition of physical defects, such as errors of refraction, imperfect hearing, malformations of the body from abnormal positions, adenoids, enlarged tonsils, and other obstructions of breathing, etc. Medical inspectors should determine the fitness of children to enter school and should recognize mental and nervous disorders.

The school nurse is now recognized as an indispensable factor in adequate school inspection service. She assists the medical inspector in his examinations and also follows up the cases and sees that they receive the necessary home and medical treatment and (if they have been excluded) are returned to school at the earliest possible time. The school nurse readily establishes communication with the homes of the children and secures the friendly coöperation of their parents. She is thus in a position to perform valuable social service. Nurses are qualified to detect the early symptoms of disease and to treat minor complaints. Ignorant parents and children will frequently repose confidence in a nurse that could not be gained by a physician.

As the medical inspection of schools is essentially public health work, especially that phase of it pertaining to the detection and exclusion of the communicable diseases, it is better that it should be initiated and controlled by the health authorities. This was recommended by the special committee of the American Public Health Association. There are certain advantages in having everything concerning the schools under the control of the educational authorities, but local circumstances and laws must decide the question.

Teachers (and some school physicians) are not experts in the detection of the early symptoms of the communicable diseases. Some instruction along this line should be part of their training. If they are suspicious of a case they should note the symptoms and report their suspicions to the visiting school physician. The symptoms may be grave or apparent enough to warrant their sending the child home before the arrival of the physician. The teacher should report to the medical inspector children who show any of the following symptoms: Loss of weight, pallor, puffiness of the face, shortness of breath, swellings in the neck, general lassitude, growing pains, rheumatism, flushing of the face, eruptions of any sort, cold in the head, especially running eyes, irritating discharge from the nose, evidence of sore throat, cough, vomiting, or frequent requests to go to the toilet.'' (Rosenau.)

If the inspection service includes school nurses they should make a general inspection of the children early in the day. Suspicious cases should be singled out from the classes and kept in a special room for examination by the physician who should visit the school in the morning as soon as possible after opening. Excludable cases may thus be detected before the children mingle together in classes and play. Complete medical inspection of each pupil is made once a year. The first examination is to determine whether the child is fit for school and can do the work without physical or mental injury. The second is a physical examination, and is preferably made with the child stripped. The child's parents should be present when this is done, or their consent should be secured. At the third examination special attention is paid to the eyes, ears, nose, throat, and teeth. The teachers are competent to carry out simple tests for determining acuteness of vision and hearing. The dental examinations should be made by dentists working in conjunction with the medical inspectors. The foregoing plan approximates the ideal, and although it is not possible in all communities, it should be adopted as far as possible.

Some cities have established school medical and dental clinics which have met with marked success.

School Exclusions. Cases of the communicable diseases such as scarlet fever, measles, chickenpox, diphtheria, whooping cough, mumps, etc., should be reported promptly to the school authorities by the health officials in order that the former may strictly enforce the rules as to the exclusion of children in infected families and houses. The rules should be made by the health officials, in conjunction with the medical inspector if there is a system of medical inspection in the schools. The health and educational authorities should coöperate in enforcing the rules. These rules vary with different authorities, the practice necessarily depending upon the nature of the disease. There are a number of minor communicable affections of children which health departments ordinarily leave entirely to medical inspectors of schools.

Rules for school exclusions formulated for public schools should also apply to parochial and private schools, Sunday schools, and other occasions of intermingling of children. They apply with special force to the primary schools, where children mingle intimately. In the higher grades the association is not so intimate and the rules may be enforced with more discretion.

"As to the exclusion of teachers living in infected families, each case should be judged on its merits. There is less contact between teacher and pupil than between pupils, and the restrictions on teachers (except, perhaps, in the kindergarten grades, where chances of contact are more frequent) need not, therefore, be so strict. If the conditions are satisfactory, they may be permitted to continue at their work. Otherwise, the case can be sent to the hospital, or the teacher may live elsewhere during the course of the disease.'' (McNutt.)

Closure of Schools. The closure of city schools on account of epidemics is of very doubtful utility. The children are practically certain to congregate on the streets and in the playgrounds where the association is more intimate, and the chances of the dissemination of communicable diseases greater than in the schoolroom. Better results are achieved by daily inspection of all school children than by closing the schools. It may be well to close the schools at the beginning of the epidemic for the period of incubation, and then open them, keeping a careful watch for new cases and guarding against the premature return of convalescents. Under these conditions the daily inspection should be held before and not after the children enter the school. If the number of cases is not decreased by closing the schools during the period of incubation, the procedure is ineffective and the schools should be reopened. The situation is similar in regard to Sunday schools, moving picture theaters, children's parties, and the like. The closing of schools means a serious economic loss to the community and is not to be lightly decided upon.

In rural districts adequate medical inspection is not readily obtained, while closing the schools does operate to scatter the children and hence lessens the opportunities of infection. In the country the children come from widely separated homes and the school is a means of bringing them together. At their homes they do not gather in groups in the streets and playgrounds; the greater contact is in the school. In view of the foregoing it can be stated that closure of the schools in sparsely populated rural districts may be effective in helping to check an epidemic.

Instruction in Hygiene. School children should receive a course in elementary hygiene in which the means of avoiding contact infection is especially emphasized. Even in the kindergarten the teachers may inculcate habits of personal cleanliness and avoidance of spreading one's secretions or taking up those of others. After children learn to read they may be given cards containing simple sanitary precepts such as the following, composed by C. V. Chapin, and used in the public schools of Providence. Placards bearing the same texts may be posted in the classrooms.

REMEMBER THESE THINGS.

Do not spit if you can help it. Never spit on a slate, floor, or sidewalk.

Do not put the fingers in the mouth.

Do not pick the nose or wipe the nose on the hand or sleeve.

Do not wet the fingers in the mouth when turning the leaves of books.

Do not put pencils in the mouth or wet them with the lips.

Do not put money into the mouth.

Do not put pins into the mouth.

Do not put anything into the mouth except food and drink.

Do not swap apple cores, candy, chewing gum, half-eaten food, whistles or bean blowers, or anything that is put into the mouth.

Never cough or sneeze in a person's face. Turn your head to one side.

Keep your face and hands clean; wash the hands with soap and water before each meal.

Instruction in the care of the teeth should be an important feature of this course.

Vaccination. Children should not be allowed to attend school until they have been successfully vaccinated. A physician's certificate or a characteristic scar is usually accepted as evidence of successful vaccination. Children should be vaccinated before entering school and again before entering high school. (Rosenau.)

Disinfection. The childlike faith of the laity and some of the medical profession, in the efficacy of room fumigation, has been well exemplified in the great pains and expense to which misguided enthusiasts have gone to purify the atmosphere of "infected schoolrooms." A certain portion of the uninformed public look upon school houses as veritable pest holes. They must be taught that the source of infection in schools is not the atmosphere of the rooms, but the mild and unrecognized cases of communicable disease which spread the disease by contact infection among the children. Most of the room fumigation as ordinarily performed in school-buildings to-day is needless and ineffective, and gives a false sense of security to parents and teachers. The best prophylactic measures are mechanical cleaning with soap and water and surface disinfection with one of the coal-tar derivative disinfectants such as cresol or with formalin solution. Objects frequently touched or handled, such as railings, door-knobs, toilet fixtures, etc., should be gone over daily with a cloth wet with one of the above mentioned solutions.

Open-air Schools. One of the beneficial results of medical inspection is the discovery of the fact that there are in every school some children who are irregular in attendance and whose work is unsatisfactory, owing to one or more of the following conditions: Incipient pulmonary tuberculosis, malnutrition due to poverty, prolonged convalescence after acute illness—or after surgical operations such as the removal of tonsils and adenoids—anemia, and want of sleep. The "open-air" school or classroom has benefited many of these children.

These schools all have the same essential features, but necessarily differ in detail. The primary requisite is an abundant supply of fresh air. The sessions are held entirely out of doors, or in rooms with windows wide open. In the newer types of school buildings rooms are designed especially for the purpose with wide windows on at least two sides, so adjusted as to be swung wide open with ease. In some schools regular rooms are utilized but with the windows always open. In others the classes are conducted in sheltered spots in the school yard or on the roof. The children are furnished with cloaks and hoods and sometimes with clothing of the bloomer type. The expense of this is or should be borne by the board of education. A large part of the day is spent by the children in these schools, and they are usually provided with nutritious food three or four times during the day. A period of rest is provided at noon during which time the children recline on cots placed out of doors.

The school exercises are subordinated to the hygienic regimen. The latter includes baths when possible.

The pupils for these classes are selected, always with the consent and approval of the parents, by the teachers, school physician, and the school nurse. They are weighed and measured before entering the new class and at frequent intervals thereafter. They are under the frequent observation of the doctor and the nurse.

The results of this outdoor life are most favorable. The children gain in weight and chest measurement, the attendance becomes regular, there is a marked improvement in their appearance and mental alertness, and they are able to make favorable progress in their school work. Undoubtedly many cases of incipient tuberculosis are arrested and many others prevented by this sanitary regimen.

Rural Schools. The problem of rural school sanitation differs from the general problem principally in the arrangements and equipment adopted to make the school sanitary. The means employed in the country must necessarily differ from those employed in cities and towns. This applies especially to one-teacher schools. Rural-school sanitation has a very wide field of influence. It should be as perfect as possible, so that the health of the children and the teachers may not be endangered by wind, rain, and insects, and also that the health of the community may not be endangered through diseases disseminated from the school by the children. The children learn directly what sanitation means, and acquire sanitary habits at school for use at home, not only while pupils in school, but in their later lives. The sanitary school serves as a demonstration of sanitation and sanitary equipment to the people of the surrounding district.

"In selecting equipment for the rural school it is necessary to bear in mind that it is to serve a wider sphere of usefulness than that of making the school sanitary. Its *adaptability to the home* should receive strong consideration. When equipment suitable to the home as well as to the school can be obtained, it should in general be selected in preference to equipment suitable for school use only. Equipment should be obtained, whenever possible, within the reach, so far as the cost is concerned, of the average family of the community." (Rapeer.)

The following is the substance of the report on the minimum sanitary requirements for rural schools proposed by the Joint Committees on Health Problems in Education of the National Council of the National Education Association and of the American Medical Association:

LOCATION AND SURROUNDINGS. The school should be located in as healthful a place as exists in the community.

Noise and all other objectionable factors should be eliminated from the immediate neighborhood of the rural school.

Accessibility. Not more than 2 miles from the most distant home; if the children walk. Not more than 6 miles from the most distant home, if school wagons are provided.

Drainage. School ground must be well drained and as dry as possible. If natural drainage is not adequate, artificial subsoil drainage should be provided.

Soil. As every rural school ground should have trees, shrubs, and a real garden or experimental farm, the soil of the school grounds should be fertile and tillable. Rock and clay soil should always be avoided. If the soil is muddy when wet, a good layer of sand and fine gravel should always be used to make the children's playground as useful as possible in all kinds of weather.

Size of School Grounds. For the schoolhouse and playground at least 3 acres are required.

Playground is not a luxury, but a necessity. A school without a playground is an educational deformity, and is a gross injustice to childhood.

Arrangement of Grounds. The school grounds should have trees, plants, and shrubs grouped with artistic effect, but without interfering with the children's playground.

BUILDINGS. The schoolhouse should be made as nearly fire-proof as possible. Doors should always open outward, and the main door should have a covered entrance; a separate fuel-room should be provided, also separate cloakrooms for boys and girls.

A basement or cellar, if provided, should be well ventilated and absolutely dry.

The one-teacher school should contain, in addition to the classroom:

(*a*) A small entrance hall, not less than 6 by 8 feet.

(*b*) A small retiring room, not less than 8 by 10 feet, to be used as an emergency-room in case of illness or accident, for a teacher's conference-room, for school library, and for health inspection, a feature now being added to the work of the rural school.

(*c*) A small room, not less than 8 by 10 feet, for a workshop, for instruction in cooking, and for the preparation of refreshments when the school is used, as it should be, for social purposes.

Classroom should not be less than 30 feet long, 20 feet wide, and 12 feet high. This will provide enough space for a maximum of thirty pupils.

VENTILATION AND HEATING. The schoolroom should always receive fresh air coming directly from out of doors by one of the following arrangements:

(*a*) Through wide-open windows in mild weather.

(*b*) Through window-board ventilators under all other conditions, except when, with furnace or jacketed stove, special and adequate inlets and exits for air are provided.

Heating. Unless furnace or some other basement system of heating is installed, at least a properly jacketed stove is required. (No unjacketed stove should be tolerated in any school.)

The jacketed stove should have a direct fresh-air inlet, about 12 inches square, opening through the wall of the schoolhouse into the jacket against the middle or hottest part of the stove.

The exit for foul air should be through an opening, at least 16 inches square, on the wall near the floor, on the same side of the room as the stove.

A fireplace with flue adjoining the stove chimney makes a good exit for foul air.

Temperature. Every school should have a thermometer, and the temperature in cold weather should be kept between 66 and 68 degrees Fahrenheit.

LIGHTING. The schoolroom should receive an abundance of light, sufficient for darkest days, with all parts of the room adequately illuminated.

The area of glass in windows should be one-fifth to one-fourth of the floor area.

The best arrangement, according to present ideas, is to have the light come only from the left side of the pupils and from the long wall of the classroom. Windows may be allowed on the rear as well as on the left side. High windows not less than 7 feet from the floor may be permitted on the right side as an aid to cross-ventilation, but not for lighting.

There should be no trees or shrubbery near the schoolhouse which will interfere with the lighting of the classroom.

The school building should so face with reference to the windows that the schoolroom will receive the direct sunlight at some time during the day.

Shade should be provided at tops and bottoms of windows, with the dark shades at top, so that the light may be properly controlled on bright days.

Schoolroom Colors. The best colors for the schoolroom in relation to lighting are:

Ceiling—white and light cream.

Walls—light gray, green.

Blackboards—black.

Cleanliness. The schoolhouse and surroundings should be kept as clean as a good housekeeper keeps her home.

(*a*) No dry sweeping or dusting should be allowed.

(*b*) Floors and furniture should be cleaned with damp sweepers and oily cloths.

(*c*) Scrubbing and airing are better than any form of fumigation.

Drinking-water. Drinking water should be available for any pupil at any time of day which does not interfere with the school program.

Every rural school should have a sanitary drinking fountain located just inside or outside the schoolhouse entrance.

Drinking-water should come from a safe source. Its purity should be certified by an examination by the State board of health or by some other equally reliable authority.

A common drinking-cup is always dangerous and should never be tolerated.

Individual drinking-cups are, theoretically, and in some conditions, all right, but practical experience has proven that in schools individual cups, to be used more than once, are unsatisfactory and unhygienic. Therefore they are not to be advocated or approved for any school.

Sufficient pressure for running water for drinking fountain or other uses in the rural school may always be provided from any source without excessive expense by a storage-tank or by pressure tank with force-pump.

Water for Washing. Children in all schools should have facilities for washing hands available at least:

(*a*) Always after use of toilet.

(*b*) Always before eating.

(*c*) Frequently after playing outdoors, writing on blackboard, or doing other forms of hand-work connected with the school.

Individual clean towels should always be used.

Paper towels are the cheapest and most practicable.

The common towel is as dangerous to health as the common drinking-cup.

Furniture. School seats and desks should be hygienic in type and adjusted to the size and needs of growing children. Seats and desks should be individual, separate, adjustable, clean.

Books and other materials of instruction should not only be sanitary, but attractive enough to stimulate a wholesome response from the pupils.

Toilets and Privies. Toilets and privies should be sanitary in location, construction, and maintenance.

(*a*) If the water-carriage system for sewage is available, separate toilets for boys and girls should be located in the schoolhouse, with separate entrances on different sides or corners of the school building.

(*b*) If there is no water-carriage system, separate privies should be located at least 50 feet in the different directions from the schoolhouse, with the entrances well screened.

(*c*) The privy should be rainproof, well ventilated, and one of the following types:

(1) Dry earth closet.

(2) Septic-tank container.

(3) With a water-tight vault or box.

All containers of excreta should be water-tight, thoroughly screened against insects, and easily emptied and cleaned at frequent intervals.

No cesspool should be used unless it is water-tight and easily emptied and cleaned.

All excreta should be either burned, buried, treated by sub-soil drainage, reduced by septic-tank treatment, or properly distributed on tilled land as fertilizer.

All schoolhouses and privies should be thoroughly and effectively screened against flies and mosquitoes.

Schoolhouses and outhouses should be absolutely free from all defacing and obscene marks.

Buildings should be kept in good repair and with whole windows.

Chapter XVI

PRISON SANITATION

The conditions under which prisoners live have been greatly improved in recent years. No civilized country tolerates the pest holes described by the great reformer, John Howard. Many "model" prisons have been erected, but there is still great room for improvement, especially in the less progressive communities. The subject is a difficult one, and has many sociological, legal, and sanitary phases. What might be possible in New York or Ohio would be utterly impossible in Alabama or Georgia, due to racial or financial difficulties. The death rate among prisoners always has been and probably always will be higher than that among men and women living a free life. The following factors contribute to this: The majority of prisoners are ill, abnormal or unusual—persons handicapped by heredity, deficient in mind or in body, victims of acquired mental disturbances, or disorganized by vicious habits, extreme poverty, or unnatural practices; the necessarily depressing conditions of prison life; in some cases, especially in States where the lease system is in use, overwork and underfeeding; long confinement in darkened cells; exposure to the communicable diseases while in prison, especially tuberculosis and in times past the insect-borne diseases, particularly typhus and the relapsing fevers. Most of these factors are in themselves predisposing conditions to the communicable diseases, more especially tuberculosis. A man suffering from "prison cachexia" is not in condition to resist any of the biological causes of disease.

Every individual, be he convict or prelate, has certain rights which must be recognized; therefore the State in depriving any person of liberty is not justified in subjecting that individual to danger of disease or death. The State has no right to shorten the life of the convict undergoing sentence of imprisonment. There is another phase of this subject little appreciated by the public. It was brought out by Lieutenant Commander Thomas Mott Osborne, U.S.N., the distinguished reform warden of the New York State Prison at Sing Sing, in quoting a prisoner in Auburn Prison: "Do people outside realize at all how the diseases we acquire in prison are spread through society? We are shut up here in these cells where a large number of men are certain to get tuberculosis; no care is taken to prevent the spread of other diseases, and then we go out and associate with people outside who sent us here, and we spread those diseases through the community, and *that is our revenge.*"

There are several social aspects of penology that should be briefly mentioned at this point. Prisoners should be properly classified according to the degree of their criminality, the nature of the crime for which they are imprisoned, or the length of time for which they have been sentenced. This has a tendency to prevent prisons from becoming schools of crime for youthful and inexperienced offenders. The sexes must be absolutely separated, and no opportunity given for intermingling in any way while in prison. The moral reason for this is obvious. There should be female attendants only on women prisoners. Male guards or other attendants should not be permitted in the female department of a prison. Neglect of this precaution has in the past and does now in some prisons lead to conditions of vice and corruption. The moral reformation of criminals belongs essentially to the social aspect of the question, but a man who is living under decent sanitary conditions, and not as a beast, is more apt to be influenced by moral suasion and religious instruction than one who is not so fortunate. Convict self-government is in the experimental stage, but the results of Osborne's Mutual Welfare League at Sing Sing and the granting of restricted liberty to selected groups of convicts with beneficial results augurs well for the future.

The Prison and Its Equipment. Manifestly in writing in a manual of this kind about an institution that varies in size from that of a one-celled country calaboose to that of the great Federal and State penitentiaries, it is impossible to make any but the most general statements; therefore only certain minimum requirements agreed upon by penologists are given.

The Building. The prison should be built upon a healthful site and at least well enough constructed to protect the inmates from rain and extremes of heat and cold. It should be screened, especially in mosquito-infested regions. Preference should always be given to a plan embodying individual cells. Dormitories and large cells have degrading influences in more ways than one. With the view to a beneficial psychic effect on the prisoners, the authorities of some prisons have eliminated the bars from the cell doors and substituted a steel door with a window and grill work. Each cell should have at least 500 cubic feet of air space and in large prisons a system of forced draught installed to insure proper ventilation. The cell should be constructed in such a manner and of such material that it can be easily kept free from vermin. Each cell should receive a reasonable amount of light and sunshine. It is to be hoped that the days of dark, damp cells and dungeons, even as places of punishment for incorrigible prisoners, are past forever. Facilities, even if quite primitive, must be provided for the prompt and thorough removal of sewage. Lavatories and baths, preferably showers, should be conveniently arranged and cleanliness enforced. If the cells contain plumbing it should be of a modern type and kept in repair.

Food. Prisoners should be supplied with a sufficient quantity of wholesome food. This need not be of superior quality, but, on the other hand, there is no excuse for feeding prisoners food of inferior quality. It should be well cooked, and the bill-of-fare varied often in order to avoid creating a disgust by the monotony of the diet. Prisoners are often subject to nausea and other digestive arrangements on account of the sameness of the daily food.

Clothing. Clothing supplied prisoners should be decently clean and should be kept free from vermin. There is a tendency to eliminate the stripes and provide a gray uniform.

Exercise. Physical culture should have a more prominent place in the prison curriculum. The physical and mental improvement of many a convict would be marked if the daily exercise in the open air that is generally required was more systematic. The popular games and sports such as baseball afford amusement and keep the prisoners out of doors, but their actual value is limited by the small number who participate. "Calisthenics or setting-up drill in which the whole population take part each day, is an ideal method, and sports for recreation and amusement should remain of secondary importance." (Christian.)

Work. It is an economy to the State and a distinct social gain to make prisoners self-sustaining citizens; therefore in all prison industries the first consideration should be training for future honest livelihood. The overworking of convicts, as was done in the mines of Siberia and in the Southern convict camps, was not only inhumane, but a serious economic and sociologic blunder. Many systems of convict labor have been tried. If the products of prison labor are thrown upon the market there is opposition from the labor unions. The State Use System seems to be the most satisfactory and causes the least criticism. Some States have convict-earning systems that afford assistance to the prisoners' families.

It is more essential that modern sanitary shop arrangements, plenty of air and sunshine, and safety appliances surround the convict workman than the free workman, as the mind and hand of the former are not as keen and active as those of the latter, and the compensation law does not include prisoners.

Farm industrial prisons, agricultural prisons, agricultural colonies, and the employment of prisoners on conservation work and at road making, are advocated by many penologists and sanitarians. These systems are without doubt to be preferred in many cases to shop work, but many problems such as climate and the employment of the prisoners in winter enter into the case.

Hospitals. All modern prisons of any size should have a well-equipped hospital, including an isolation ward, and a competent resident medical staff, which should include an experienced psychologist and a dentist. The advice and assistance of a consulting staff including a surgeon, an oculist, a genito-urinary specialist, a neurologist, and an alienist should be available.

The Communicable Diseases. Cases of communicable diseases entering or occurring in prisons must be isolated. Tuberculous patients must be prevented from spreading the infection, and all modern measures to this end, as far as the facilities of the prison permit, should be provided and the necessity for their use explained. Some of the larger prisons are now equipped with sanatoria for the treatment of tuberculous patients. Venereal cases should receive thorough modern treatment and be instructed as to the danger to others and the prevention of their infection. The statutes of the State of Virginia permit the Governor of the commonwealth, upon application of the superintendent of the penitentiary, when requested in writing so to do by the physician of that institution, to have removed from the penitentiary for proper treatment and isolation elsewhere any prisoner suffering from a communicable disease dangerous to the public health. The judges of the county and corporation courts are likewise empowered to act in the same manner in regard to prisoners in the county and city jails.

Chapter XVII

INDUSTRIAL SANITATION

Industrial hygiene or sanitation is that large branch of preventive medicine which has to do with the health of the worker as it may be influenced by his activities and environment. In its broadest sense it includes the general sanitary and hygienic conditions under which he lives as well as those under which he works. As the workers comprise by far the largest part of the body politic, industrial hygiene, from the standpoint of the sanitarian, is simply a special application of the general principles of preventive medicine to the most numerous element of the population. The subject is closely interwoven with many of the most pressing economic and social problems of our times.

The true *industrial* or *occupational diseases* are the maladies due to poisonous and irritating gases, vapors, dust, or other mechanical irritants, to exposure to high temperatures and abnormal atmospheric pressures, the special uses of nerves and muscles, and to parasitic infections, resulting from specific conditions of labor. The study of their causes, symptoms, and modes of prevention is known as *vocational hygiene*. The reporting of occupational diseases is an important public health measure, and is now required in some of the States and in a number of the European countries.

Conditions in Industrial Life Predisposing to the Communicable Diseases. Aside from the direct exposure to a limited number of infectious agents as a result of specific conditions of labor, the environment, activities, and materials handled by workers frequently predispose them to the communicable diseases. Overcrowding in factories, workshops, and other places of employment favors insanitary conditions and increased danger from direct and indirect contact infection. Until corrected in a measure by recent legislation, the conditions of overcrowding in the sweatshops and other places of employment of the clothing trade were unspeakable. Many factories and workshops are still overcrowded, dirty, dark, and poorly ventilated. The sanitary conveniences of many factories leave much to be desired. The excessively heavy labor undergone by many workers predisposes them to disease. The same applies to long working days, to the nervous strain due to "speeding up," and, especially among women, to inconsiderate treatment by employer or foreman. The harmful dusts, vapors, and moisture of many trades predispose the workers to respiratory troubles and especially to tuberculosis.

Neglect of the Principles of General Hygiene. All of the ills of workers should not be attributed even indirectly to their occupations. Many ignorant and careless persons will neglect the first principles of hygiene when surrounded by the most sanitary conditions. They will eat their lunch or leave the factory without washing their hands when that factory is equipped with ideal washing facilities. They tolerate in their own homes and communities insanitary conditions with which their employment or employer has nothing to do. In their life outside the factory or workshop they are liable to infection through contact, water, or food the same as others. Many become infected or predisposed to communicable diseases through dissipation and vice.

The discussion of the occupational diseases *per se* and of vocational hygiene are not within the province of this work; only those measures tending toward the general welfare of workers and the prevention of the communicable diseases will be described.

Sanitation of Factories and Workshops. Among the delusions from which the American public has suffered, and which are now being rapidly dispelled, is one to the effect that our laboring people and artisans work under more favorable conditions than do those of Europe. Such is far from being the case. In many instances the sanitary conditions in our places of employment are more like those of Asia than of Europe. It is only within recent years that labor legislation has been undertaken by our legislatures. Factory inspection is frequently lax or non-existent. A comparison of the morbidity rates for occupational diseases in the corresponding trades in America and England is most unfavorable to the American factory.

Improvements in the sanitation of factories and workshops have demonstrated that while certain occupations must necessarily be dangerous, in spite of reasonable precautions, because of poisonous minerals or chemicals or harmful dusts, gases, or vapors evolved, many occupations hitherto classed as unhealthful have been so because of the failure to maintain ordinary sanitary precautions and to provide proper apparatus for adequate ventilation, removal of dust, regulation of humidity, etc. (Egbert.) Tuberculosis and other infections will rapidly spread in any factory or shop that is dark, poorly ventilated, and dirty, and in which sanitary rules against promiscuous expectoration are not enforced.

Efficient factory inspection is essential in order that the welfare of employees and the public and the rights of employers may be protected. The inspectors must be conversant with the law as it applies to the occupation and particular place in question, and they must note the presence or absence of all that makes for better work, better health, better living, and for such a sanitary state that, excepting what is unavoidably inherent in the nature of the occupation, there can be no excuse for origin or persistence of disease in that factory or shop. (Egbert.) Inspectors must note the ages and hours of employment of working children; they should advise—and where they have the authority, insist—upon such devices as will protect the workers against preventable accidents as well as harmful poisons, dusts, and vapors. They should collect and collate facts and data upon which social and economic progress may be advanced and labor legislation may be based.

Ventilation. A number of factors are instrumental in causing deterioration of the air in industrial establishments. The presence and breathing of the workers causes a decrease of oxygen, increase in the relative amount of carbonic acid, increase in the amount of moisture, increase of temperature, and increase in the relative amount of organic matter in the air. The condition of the place of work may unfavorably influence the atmospheric conditions. Detritus from walls, floor, ceilings, and other surfaces; increased humidity due to dampness of the walls and other parts of the buildings; molds, fungi, and other low forms of organic life cause deterioration of the air. Artificial lighting and the heating of rooms cause increase in the relative amount of carbonic acid in the air and an increase in the temperature. The temperature is increased by the motion and friction of machinery, etc., and the waste and detritus from tools, stones, machinery, etc. Waste from the crude materials which are torn, crushed, ground, milled, polished, etc.; dust from organic and inorganic substances of manufacture; poisons, fumes, and gases, infective agents, bacteria, etc., pollute the atmosphere.

Ventilation by perflation and by the additional means of the ordinary openings in buildings, such as windows, transoms, and doors, may be adequate for very small workshops with a very limited number of workers, but is inadequate for larger shops and factories. Special artificial openings made for ventilating purposes, such as special outlets, chimney flues, cowls, etc., are likewise insufficient in the larger workshops and factories, especially in those in which dust, gas, and noxious fumes are produced in the processes of manufacture and industry. In such cases dependence must be placed upon mechanical ventilation.

In the mechanical ventilation of factories and workshops the vacuum or extraction and the plenum or propulsion systems, and combinations of the two are in common use. In the propulsion method additional means may be provided for warming the incoming air to a desired temperature, and also for regulating its relative humidity. In the extraction method means must be provided for collecting the impurities of the extracted air in proper receptacles, for clearing the air of dust, etc., by filtration, precipitation, or compression, and for the absorption of gases, etc., by chemical means.

"Ventilation by fans, by which is meant mechanical ventilation, has very great advantages over all other methods of ventilation, and should be resorted to in all large industrial establishments where there are a great number of workers, and where the processes of industry develop large quantities of various impurities. Ventilation by fans can be easily installed in any industrial establishment where some motor power, such as compressed air, steam, or electricity may be conveniently had. Not only are the quantities of air which may be supplied by fans practically unlimited and the supply under perfect control, and not only may provision be made, as stated above, for warming the air and removing dust, etc., but there is the additional advantage of the possibility of removing dust, fumes, etc., at the *very point* where they are given off. This is an absolute necessity in some industries where the amount of dust given off or the fumes generated would be injurious to health if not promptly removed.

"The proper ventilating devices for removal of dust consist of the following:

"(1) An expansion hood, box, or cap, properly fitting or enclosing the tool, machine, or stand of each dust-producing process or worker.

"(2) Tubes or ducts connecting with the above-named hoods, etc., and leading to the outlets.

"(3) The fans proper, which are at the ends of the outlet, tubes, or ducts, and which serve to exhaust and extract the air with the dust from the tubes, hoods, etc.

"(4) Receptacles into which the dust settles by gravitation, centrifugal motion, etc., after it is extracted. Various other appliances, such as those for wetting the air, etc., may be connected with the apparatus.

"For purposes of general ventilation the exhaust or propelling fans may be placed in one or two parts of the building without regard to local ventilation of the individual industrial processes. It is needless to say that the installation of a ventilating apparatus demands proper engineering knowledge and skill, and a detailed calculation of the various conditions arising in the process." (Price.)

Legal minimums of from 250 to 400 cubic feet of air space per occupant have been established by different legislatures. This is entirely inadequate; as a general rule there should be at least 1000 cubic feet of space for each individual, and this should be increased in especially dusty or otherwise dangerous employments.

The walls, ceilings, floors, and other surfaces of factories and workshops should be constructed with due regard to the industry carried on. Where large quantities of dust are involved, the walls and especially the floors should be made of smooth material, such as glass, tiling, etc., which can be easily cleansed; and all corners, crevices, and nooks where dust may accumulate, should be avoided. In factories where the humidity is high, the walls, ceilings, and floors should be made of impervious, non-absorbent material. Concrete, cement, asphalt, tile or artificial stone are the best materials for factory floors. In places where large quantities of water are spilled upon the floors they should be so graded and drained as to discharge all the water into special pipes, not, however, connected with the general plumbing system of the building.

Lighting. Good daylight, and especially direct sunlight, not only purifies the air, but improves the cheerfulness of surroundings and the morale of the worker. The proper lighting of factories and workshops influences favorably not only the condition of the eyesight of the workers, but their general health as well. Many modern factories are constructed with walls composed largely of glass in iron frames. This has done much to promote health and efficiency. The area of factory windows should be at least one-third of the wall area, and one-sixth of the floor space. For the best results in general artificial lighting, factories should have light-colored smooth walls for reflection and lights, backed by reflectors, suspended near the ceiling. In artificial lighting of workrooms in general this overhead system is best, with lights placed well above the natural level of the eye. In some cases, however, side illumination is essential, and beams, walls, girders, or partitions, when painted white, may often be utilized to reflect and diffuse light, and, also, in some cases, to conceal it and prevent the glare which causes so much fatigue of the workman. When the nature of the work requires the use of strong light very close to the operator it should always be so placed and screened as to prevent injury to the eyes. (Thompson.)

Electricity is undoubtedly the best artificial illuminant, as it gives the best and strongest light, adds no impurities to the air, and does not raise the temperature of the room. Next to electricity the best lights are those given by the Welsbach and similar gas burners. They should be uniformly distributed and not placed too near the persons of the workers.

Washing and Bathing Facilities. Factories and workshops should be well equipped with stationary wash stands for washing the hands and face. In the dusty metallic industries there should be facilities for cleansing the teeth as well. Wherever possible both hot and cold water should be supplied. This is highly essential in lead works, chrome works, and similar extra-hazardous industries. These, and chemical works generally, should have overhead shower baths for the workers. There should be ample washrooms for each sex on every floor in every work place, and the fixtures should be of the best and most modern type. Washrooms should be supplied with individual towels and never with roller towels. In the better class of factories paper towels are coming into general use.

Toilets. There should be separate toilets for the sexes on each floor. The factory laws of several States require a minimum of at least one closet for each twenty-five persons of each sex. The toilet fixtures should be of improved modern types, and should be under the constant and especial care of proper persons, for these fixtures are liable to be abused when used by a large number of persons. The floors of toilet rooms should be of impervious material, preferably cement, and the rooms should have access to daylight and outdoor air. The toilet bowls and urinals should be washed daily with a disinfectant.

Cuspidors. The spitting habit should be discouraged among workmen, but as it bids fair to persist, cuspidors should be provided. The most sanitary cuspidors are flat boxes of wood or metal, at least a foot square, filled with dry sand or sawdust, which should be renewed frequently. Heavy penalties should be imposed for expectorating anywhere else than in a cuspidor.

Recreation. Every worker should have one full day's rest each week. One of the most favorable signs of social progress is the present tendency to divide the day into eight hours of work, eight hours of recreation, and eight hours of sleep. Workers can and do work more than eight hours a day without harm to their health, but that is no reason for their being compelled to do so. A human being should have as much right to a reasonable amount of leisure as he has to air and water. It is impossible to lay down a general rule for the hours of work; they must depend upon the character of the employment, upon the physical exertion required, and the nervous tension under which the workers labor. Vacation periods with full pay; Saturday half holidays, especially in summer, and the increase in the number of holidays granted in recent years have improved both the health and the efficiency of workers.

Employment of Women and Children. The conservation of the health of women and children by restricting the number of hours of work and prohibiting their employment in distinctly dangerous surroundings is essential to the welfare of the race. During the Great War the women workers did the same work as men with the exception of that requiring the greatest muscular strength. This does not justify the continuation of the practice after the demobilization of the army. The protection of women is especially important during the period of maternity. Pregnant women should not work for several weeks before labor and for at least a month after labor. Women workers should be on full pay during this period. Reasonable allowances should be made for absence or lessened work for several days each month on account of menstruation.

In many of the States the minimum age at which children may begin to work has been fixed at fourteen years. In Massachusetts it is now eighteen years, and in some instances twenty-one years. In that state the State Board of Health has received power to declare from time to time whether or not any particular trade, process of manufacture, or operation is sufficiently injurious to the health of minors under eighteen years of age to justify their exclusion therefrom. The Board of Health also has the power of discretion to determine whether such processes may not be carried on with reasonable safety when certain precautions are observed and guaranteed.

Pennsylvania requires that children at work between the ages of fourteen and sixteen shall attend continuation schools for a specified number of hours per week, the hours of labor being limited accordingly.

A number of the States regulate the number of hours per day and per week which the child may work, and some prohibit work at night, especially by girls, and in certain dangerous trades and in occupations involving exposure to temptation. (Egbert.)

Direct Exposure to Infectious Agents. The chief communicable diseases to which workers are exposed as the result of specific labor conditions are: ankylostomiasis, anthrax, glanders, foot-and-mouth diseases, septicemia. Their prophylaxis is described in Part II.

Ankylostomiasis. Miners and agricultural laborers are exposed to infestation with the hookworm. A temperature of 80° to 90° F. is most favorable to the parasites, hence they do not thrive in cold or temperate climates outside of mine or tunnel protection. During the construction of the St. Gothard and the Simplon tunnels the disease was so prevalent as to assume epidemic proportions. Workmen of uncleanly habits defecate in the tunnels and pollute the soil. The gold mines of California and Nevada have been infected by workmen from Italy and Austria. The disease is very common among the rural population of our Southern states, affecting especially farmers, brickmakers, tunnel workers, trench diggers, and similar classes of persons who come in contact with infested soil. These people frequently go barefooted and nearly always pollute the soil around their houses, hence the wide prevalence of ankylostomiasis.

Anthrax. The spores of anthrax cling to the hides of animals that have died from the disease or have been slaughtered on account of it. Anthrax is seen in butchers, shepherds, cattle salesmen, meat inspectors, workers in horsehair, camel's hair and hair brushes, tanners and those who transport hides or wool, and especially in wool carding and spinning. Anthrax is rare in this country, most of the cases being infected by hides or hair imported from Asia.

Glanders. Glanders occur among hostlers, horseshoers, and teamsters. A number of serious localized epidemics have been reported in cavalry regiments of the army.

Foot-and-mouth Disease. During epizoötics of this disease butchers, cowboys, drivers, stablemen, and horse dealers are occasionally infected.

Septicemia. Workmen engaged in the handling of putrid or decomposing animal products are exposed to the dangers of septic infections. Workers in the tallow industry and those employed in the making of bone fertilizers are in special danger of these infections.

Tuberculosis. Many of the conditions of industrial life such as long working hours, fatigue, poorly ventilated workrooms, irritating dusts and fumes predispose to tuberculosis. It is hardly correct to speak of tuberculosis as an occupational disease, but nevertheless it is the most serious problem in industrial hygiene. Bad sanitary and hygienic conditions in factories and workshops light up latent infections and the disease cannot be arrested while the patient continues under those conditions. The trades which involve the greatest exposure to dust and irritating vapors furnish the largest number of tuberculosis victims. Among these are the following: stone cutters, millers, bakers, grinders, engravers, glass cutters, brass workers, furriers, weavers, and plasterers.

Instruction in Personal Hygiene. Industrial plants of the better class now offer systematic instruction to their employees in personal hygiene. This is imparted by illustrated lectures, demonstrations, and by placards posted in conspicuous places around the institution. Useful information is given as to the care of their health and the prevention of accidents while at work, and also as to domestic and social hygiene.

The Industrial Physician. Many of the larger industrial institutions now have physicians, nurses, and some of them dentists as part of their staff. The duties of the industrial physician are extremely varied. He renders first aid in cases of accident and sickness; if the plant has a hospital he cares for the sick and injured; he plans and executes the extension of health service in the industry; he develops an adequate system of medical supervision of employees; makes reports to the health authorities of the prevalence of communicable and occupational diseases; studies and applies the results of his studies of vocational hygiene and industrial sanitation to the industry in question; and has general medical supervision of the industrial establishment and in certain cases of the homes of the employees.

An important duty of the industrial physician is the physical examination of workers. The purpose of this examination is to obtain information that will enable physicians (a) to assist in placement and replacement of workers and (b) subsequently to assist and advise both employers and workers in the maintenance of the workers' health, the former in order that he will not cause the workers to labor under conditions that may be unfavorable to their health, and the latter in order that they may live as well as labor without impairment of health. (Selby.)

The industrial nurse aids the physician in his work and is especially valuable in rendering aid and giving advice in the families of the workmen. The work of the industrial dentist is largely of a preventive nature. He makes periodic examinations of the teeth of the employees, makes such fillings and gives such treatment as will tend to prevent serious dental troubles and infections and gives advice as to such more elaborate dental work as may be indicated.

Chapter XVIII

EXOTIC HYGIENE AND SANITATION

Arctic Sanitation

There are no diseases peculiar to very cold climates. Certain conditions predisposing to communicable diseases are, however, present. These include overcrowding and poor ventilation of habitations, improper food or lack of fresh food, vermin, and too intimate association with animals and diseased persons. These seem to be more than offset by the pure, sterile air, low temperature, and sparse population, conditions unfavorable to the growth and dissemination of pathogenic organisms. The Eskimos, who are the filthiest people in the world, seem to enjoy astonishingly good health. Tuberculosis is unknown among the primitive Greenland Eskimos, but they soon develop it when brought south. They recover when returned to their Arctic homes. Venereal diseases spread rapidly when introduced, due to their promiscuous intercourse, but soon die out. Dr. Nicholas Senn attributed their recovery from syphilis and the rarity of such degenerative diseases as arteriosclerosis, cirrhosis of the liver, chronic nephritis, cataract, etc., to the ingestion of iodine which is present in sea-food.

The pandemics of influenza involved the Eskimos and many died of it. Some years ago an epidemic of Arctic dysentery swept through the Arctic regions from Finland via Siberia to Cape Barrow and reached Hudson Strait. Dr. Senn suggested that the germs were carried by migratory birds, as the Eskimos relish a large louse that infests the little auk, the most common of the Arctic fowl. Wounds heal readily without suppuration, no doubt due to the intense cold. Dogs, with which the Eskimos live in such close association, are the hosts of the tape worm, *Tænia echinococcus,* which is the parasitic cause of echinococcus disease. This is common in Iceland, but not in Greenland.

Sanitation is not difficult in the Arctic and Antarctic regions. Excreta freeze almost instantly and become inoffensive and innocuous. In the subarctic regions there is danger of pollution of the water supply in the spring and summer, when melting snow may wash into it the excrement that has been indiscriminately scattered in the neighborhood during the intensely cold weather. Drinking water should always be taken from points above any possibility of such contamination. When occupying huts, snow or wood, some of the exploring expeditions have used for defecation a cave running off from the snow tunnel leading to the hut. While on the march the snow hut occupied the previous night has been used in the morning for a latrine. Sometimes men have been unable to leave huts or tents for weeks at a time on account of severe weather. In such cases it was necessary to urinate and defecate inside the structures.

Snow and ice themselves should not be used to quench thirst, as they detract from the heat of the body and may irritate the mouth and throat. Melted snow and ice, when heated, are a good water supply.

The food supply of Americans and Europeans in the Arctics consists of canned goods, supplemented by such fresh food, principally game and fish, as can be procured. There is evidence to show that fresh meat, as well as fresh vegetables, is efficient in preventing and curing scurvy. Food should, if possible, be eaten hot, thus conserving the heat of the body.

Men fed on compressed food for a long time develop diarrhea when given fresh meat. Ptomaine poisoning occurred in the Shackelton party from eating pony meat which no doubt had undergone some putrefaction. The same trouble has been caused by the use of improperly cleaned cooking utensils. Sea water ice, used for the salt it contains, will sometimes cause diarrhea.

The personnel of Arctic expeditions have suffered very little from communicable diseases. Some have been free from coryza until coming into touch with other Americans or Europeans aboard ship. Rheumatism, lumbago, and sciatica occur among whalers and in expeditionary outfits. Constipation with resulting hemorrhoids is also annoying. This is due to compressed food and at times lack of exercise. It is not so frequent when bulky food containing large quantities of fat is eaten.

Tropical Sanitation

The continued high temperature and often excessive humidity of the tropics are ideal conditions for the growth and multiplication of disease-producing microörganisms and the higher forms of animal parasites. The customs, habits, and manner of living of the natives, the abundance and variety of insect life, and the pollution of water supplies conduce to the spread of infection by all the known means. The conservatism, inertia, and profound ignorance of the people, their indifference to sanitation, their extreme poverty, the often uncertain and poor food supply, their filthy surroundings, the density of population with the crowded condition of habitations in many tropical cities all favor the rapid spread of the diseases characteristic of the tropics and of those introduced from temperate climates. These conditions have helped to keep alive in warm countries leprosy, bubonic plague, and cholera, which have largely died out in cooler latitudes.

From the foregoing it is apparent how serious is the error of conforming, in matters of hygiene, to the habits of natives of tropical regions. This has been advocated as the safest way to live in warm climates, but has cost many white men and women their lives.

A full discussion of tropical hygiene would be out of place in a work devoted to the communicable diseases. Only the sanitary measures necessary to prevent the latter in the tropics will be described.

Prophylaxis against Infection by Contact. In the tropical and subtropical zones, where the civil authorities are in many cases unable or unwilling to protect the individual from infection, personal hygiene becomes of even greater importance than in cooler climates. It is only by strict adherence to its rules that illness and possibly death are avoided.

Americans and Europeans living in the tropics should occupy isolated or detached houses or quarters and avoid intimate association with the natives, many of whom are carriers of grave infections and suffer from serious parasitic skin diseases. Especially should white children be kept from unnecessary contact with native children.

In hot countries, where vermin abound, the sanitary cleanliness of living quarters, especially the bathrooms, water-closets, kitchens, etc., is of prime importance. The dangers from insects and other vermin and from indirect contact are thus minimized.

Men newly arrived in the tropics are stimulated sexually by their strange environment, habits of dress and conduct of the natives, the heat, etc., and are prone to sexual excesses, with the practical certainty of sooner or later contracting one or more of the venereal diseases. This, of course, can be avoided, as in any other part of the world, only by sexual continence or marriage, cleanliness of the genitals and only handling them for the proper purposes, and the avoidance of indecent and obscene surroundings, pictures, and company.

Infection by Insects and Other Vermin. It is in the tropics that the greatest dangers from this source lie, and there the greatest triumphs in overcoming them have been achieved. By the eradication of yellow fever and malaria from the Isthmus of Panama the digging of the canal became possible. By the same means great stretches of country in Africa and South America will become homes of the white race.

At the risk of repeating much that has been stated and discussed in other sections, a short *résumé* of prophylactic measures against insects and other vermin, as applied to the tropics, will be given.

Mosquitoes. These insects are the great scourge of hot countries. They are present throughout the entire year, and are not only a perpetual annoyance, but transmit malaria, yellow fever, dengue, and filariasis. Extraordinary public measures are taken only against a genus transmitting a disease which is endemic or epidemic in a given locality. For safety and comfort in the tropics careful attention must be paid by the individual to the protection of his premises and his person, and the avoidance, if possible, of being bitten by *any* mosquitoes.

In the tropics, as elsewhere, the mosquito-borne diseases are not present in districts having good urban and rural sanitation. Good water supply, good drainage, good paving, good building organization, the proper disposal of sewage, and an efficient sanitary service empowered to enforce the necessary sanitary routine will prevent or abolish malaria and yellow fever. Where sanitary precautions are neglected and vessels containing water allowed to collect and pools and puddles allowed to form around buildings, mosquitoes are sure to breed.

Good general sanitation is impossible unless good domestic sanitation is practiced. The occupants of a house or bungalow in a tropical town or village should be held responsible for keeping their premises, as far as possible, free from mosquito-breeding conditions. This can be done only by frequent inspections by the health department.

Householders should see that there are no pools of water on the premises and that all rubbish, such as broken bottles, empty cans, etc., that may retain water, is promptly removed. The immediate surroundings of kitchens and servants' quarters require particular attention.

Wells, cisterns, tanks, and rain barrels should be covered with fine wire screen. Privies and cesspools should be screened and treated once a week with an ounce of petroleum to every 15 square feet of surface. Flush tanks of closets not in use should be flushed several times a week or be protected with screens.

The doors, windows, and other openings of houses should be closed with screens of copper wire, nineteen strands to the inch. The doors should be double, forming a vestibule, self-closing, and so arranged that both cannot be open at the same time. The screens must be close fitting and kept in good repair. Native servants are apt to open the screens in the cool of the morning, the very time mosquitoes are seeking dark shelters for the day. This, and the fact that a few enter as people pass through doors, accounts for the presence of some mosquitoes in properly screened houses. Frequent inspections should be made, and if a room becomes infested it should be fumigated with SO_2 or pyrethrum.

Thick curtains form favorite lurking places for mosquitoes. Clothes hung up should be shaken out and placed in the sun once a week.

Gardens should be so managed as not to become breeding places for mosquitoes. No stagnant water should be permitted. Heavy creeping vines and thick shrubs placed around verandas are ideal resting places for the insects, and also cut off the breeze. Light growths of vines around verandas do not harbor so many mosquitoes, give a pleasant shade, and do not cut off the breeze.

Mosquito nets or bars are our chief defense, acting in two ways: (1) By protecting individuals from contracting mosquito-borne diseases; (2) by preventing patients from becoming a source of infection to others. To be properly protected by a mosquito net the bed should be broad, so as to leave some space between the sleeper and the net. The sides and ends of the net should be inside the poles, and the lower border tucked well under the mattress and not hanging on the floor. If the net is not wide, the lower 12 inches should be lined with calico so as to protect the arms and legs in case they come in contact with the net during sleep. During the day the net should be folded or twisted so that the inside is not exposed, and it should be let down late in the afternoon and inspected for mosquitoes, and the slightest hole repaired at once. On retiring one should enter the net quickly and through as small a space as possible, thus preventing the entrance of mosquitoes. It is well for travelers to carry in their hand baggage a head net for use in an emergency.

Mosquitoes will bite through very thin cotton clothing. In infested districts the ankles should be protected by high shoes, especially in the evening. Women in evening dress with low-neck gowns, thin silk stockings, and slippers are easy prey for the anophelines.

In the evening, if a well-screened veranda is not available, one should sit near the electric fan or beneath the punkah. The latter is a rectangular frame covered with cloth from which hangs a wide flounce. It is suspended from the ceiling by cords and is kept in motion by a rope which passes over a wheel and is pulled by a boy.

The essential oils and other volatile substances applied to the skin of the face, neck, hands, and other exposed parts have only a limited value, their effect wearing off in a few hours. When really hungry, mosquitoes will overcome their distaste for all such applications.

The destruction of mosquitoes and their larvæ is discussed in the sections, "General Prophylaxis," and "Insecticides."

Fleas. Certain conditions prevailing in the tropics, such as dirty houses and people of uncleanly habits, favor the multiplication of these insects. Full consideration has been given the Pulicinæ and the measures necessary for protection against them under "General Prophylaxis" and "Plague."

Pulex penetrans, the sand flea, or chigger, haunts dry sandy soil, the dust and ashes in badly kept native huts, cattle stables, poultry pens, etc. It attacks all warm-blooded animals, including birds and man. It causes much suffering, invaliding, and death. It is extremely prevalent among the Indian coolies on the East Coast of Africa, by whom it has been brought to India.

To avoid chiggers one should never walk about the house or camp in bare feet. Sandals and partly worn-out slippers are insufficient protection. The insects attack chiefly the feet. To prevent their occurrence in habitations the floors should be swept daily and washed regularly with soft soap and scrubbing brush or one of the coal-tar disinfectants.

Flies. The common house fly, *Musca domestica,* is abundant, and its allied species, the lesser house fly, the blow fly, the blue-bottle fly, and the flesh fly are occasionally found around living quarters in hot countries. The African trypanosomiases are transmitted by certain species of flies, *Glossina moristans* and *Glossina palpalis.*

The common fly is a grave danger in the tropics because of its liability of mechanically transmitting the fecal-borne diseases. The larvæ of flies cause a disease, myiasis, in which the eggs are laid by the flies in the ear, nasal cavity, or abrasions of the skin. Its prevention consists in protecting wounds and sleeping under a net.

In some parts of the tropical zone the favorite larval food of the house fly, horse manure, is scarce, being used for fuel. In this case the flies breed in human and dog excrement and decaying animal and vegetable matter. Flies breed in relatively small numbers when fermentation in household refuse has not developed. If receptacles are emptied at short intervals breeding will be prevented. They are not harbored by very dry or wet ashes or moist cow dung. As a general rule the presence of flies in a house means that filth is near at hand.

Chickens, but not ducks or geese, destroy the larvæ and pupæ of flies. Other natural enemies of *Musca domestica* found in the tropics are centipedes, spiders, certain beetles, and certain varieties of ants.

Prophylactic measures against the house fly in the tropics differ in no way from those applicable in the temperate zones. Sanitary measures concerning the Glossinæ are discussed under "General Prophylaxis" and "Sleeping Sickness."

Lice. Three species of lice infest man in the tropics, as in other parts of the world. Prophylaxis against the body louse, *Pediculus vestimenti,* is important, as it transmits typhus fever and relapsing fever. Proof is now conclusive that the head louse, *Pediculus capitis,* transmits the same diseases. Preventive measures are the same in warm countries as elsewhere.

Ticks. These Arachnidæ are widely distributed and play an important part in the transmission of disease. They may convey disease in any stage of their development. Some varieties lay eggs that produce larvæ which are infective. The grass of some districts is infested with the larvæ which cling to passing animals.

Ticks live in native huts, especially in Africa, hiding in the thatched roofs, cracks, and crevices of the floors and walls during the day and feeding on the blood of sleeping persons at night.

The African tick fever closely resembling relapsing fever, is disseminated by *Ornithodrus moubata,* and a severe form of fever common in Southern India is credited to *Ornithodorus savignyi.*

Prophylactic measures against the tick are based on domestic cleanliness. To avoid their bites keep away from native huts, especially at night. In tick-infested regions one should not sleep on the ground; the bed or cot should be raised well off the ground, and the sleeper protected by a properly arranged mosquito net. A night light aids in keeping ticks away. When traveling the legs should be protected by leggins or hunting boots, as the larvæ inhabit the grass and brush. Bedding should be packed in insect-proof metallic cases.

Bedbugs. The Cimicidæ have almost a world-wide distribution and are very plentiful in dirty houses, particularly in tropical towns. They transmit kala-azar and probably relapsing fever and typhus.

Preventive measures are described under "General Prophylaxis" and "Insecticides."

Water. Pure water for drinking purposes is not easy to obtain, in many parts of the tropical world. This is largely due to the pollution to which water is subjected by the customs and habits of the people. In warm climates bacterial and protozoal parasites exist in greater number and variety than in cooler latitudes, where the conditions are not so favorable to their growth and multiplication. In the tropics water transmits not only the diseases and infestations characterictic of the temperate zones, but cholera, dysentery, and the metazoal parasitic affections peculiar to hot countries. These diseases are disseminated not only by drinking the infected water, but by its use in washing dishes, cooking utensils, green vegetables, fruit, etc. Impure water may also transmit oriental sores, ring worms, and other skin diseases when used for bathing.

In some of the larger tropical cities, among others Manila, modern water works have been installed. However, it is better to regard all water in the tropics as infected, especially with amœba.

Where there are no streams, water is generally obtained from shallow, uncovered wells. These are certain to be contaminated, as the immediate surroundings are used as the public laundry and bath. Each person uses his own bucket and string, and as these are always dirty, they have been a factor in the spread of cholera. The streams also serve as public baths and laundries.

Cisterns are necessary in many localities; they should be cement-lined and above ground, so that they can be easily and thoroughly cleaned. The cover should fit tight enough to exclude light, small animals, and insects. The first water from the roof is very foul, and should invariably be rejected. The overflow pipe should discharge into the open air and the opening should be screened. Cistern water should, like all other drinking water in the tropics, be considered unsafe until purified.

Boiling is the best method of domestic purification of water. It should actually bubble for twenty minutes, and the operation should be superintended by a responsible person. If possible it should be boiled in the vessel in which it is to be cooled. Unglazed earthenware jars are satisfactory, and water so boiled in the evening will be cool by morning, especially if the jar be placed in a draught. It is well to store boiled drinking water in bottles on ice. There is some danger of placing ice, even if made from distilled water, in drinking-water, as it may be contaminated in handling. The flat taste of boiled water is largely avoided by partly filling the bottles and shaking them, thus aerating the water. Water should never be filtered after being boiled, as there is some chance of contamination while passing through the filter. If the water is turbid or muddy, it may be filtered or strained before boiling. Suspended matter may be precipitated by alum, 6 grains to the gallon.

At many naval stations and army posts in the tropics the water is distilled at a central plant. This is eminently satisfactory.

The bottled aerated waters are refreshing and useful in the tropics. Only the standard brands, whose purity is above suspicion, should be used.

The usefulness of various filters and sterilizing methods, heretofore described, extends, of course, to tropical conditions. The chemical purification of water may be used to a limited degree as a domestic measure. The permanganate of potassium method is used in India, and is a practicable method for small bodies of explorers, engineers, sportsmen, etc., living or traveling in the tropics.

Nowhere is personal cleanliness and bathing so important as in the tropics, where skin diseases are rife and perspiration free. The bath, preferably the shower bath, is absolutely essential to comfort and health. By this means and careful attention to cleanliness of the hands before eating, and visible and occult sources of contact, infection may be largely avoided. The bath water should be of sufficiently high temperature to avoid chill, which has a tendency to arouse latent malaria and dysentery. After the bath the body, especially the arm pits, crotch, and groins should be well dried and sprinkled with talcum powder. To avoid dhobie itch and other tropical ring worms, boils, chafing, and prickly heat, the above mentioned parts should be gently mopped with a weak solution of bichloride of mercury or formalin after the bath.

If a tub or tank is used for bathing, only one person should use the same tub or tankful of water, as skin diseases are transmitted in this manner.

The water-borne diseases and infestation with animal parasites are contracted by swallowing polluted water while bathing in streams or ponds. Great care is needed to avoid this danger while traveling or marching through inhabited districts.

A bath on rising and one after the work of the day is over are almost essential in the tropics. To many people a bath before retiring is soothing to the nervous system and induces sleep. The bath water should be boiled if possible, but if impossible, reasonable care should be taken not to swallow any of the water. The teeth should be brushed only with boiled or distilled water. Enemas and douches should be prepared only from safe water. Swimming pools are likely to be infected with the germs of fecal-borne diseases. Ocean bathing, in the cool of the evening, is one of the most healthful and invigorating of all exercises and recreations.

Food. In warm countries one must be temperate in the matter of eating, as overindulgence in food, as well as eating indigestible food, leads to a catarrhal condition of the digestive tract, which predisposes to cholera and dysentery. A light breakfast and lunch, with the heavy meal—consisting of a regular course dinner—after sunset, is the most salutary routine.

A person's diet must be regulated by the work he does. A hard-working American or European cannot thrive on the rice, fruit, chicken, and fish diet of the natives of tropical countries.

Constant vigilance is required to prevent the dissemination of communicable diseases by infected food and the causation of ptomaine poisoning by putrified food. All animal food, especially milk and fish, rapidly spoils in the tropics. Milk should be sterilized as soon as drawn from the cow, goat, or buffalo, as it is liable to be infected with the germs of cholera, dysentery, and in the case of goat's milk, Malta fever. To these dangers must be added that from diseases transmitted in a similar manner in temperate climates. The native milkman is generally unclean; he dilutes the milk, and usually with questionable water. In some countries the cow or goat is driven to the houses of Europeans and there milked. It is best to use one of the excellent brands of canned milk now on the market.

Among the native populations who have no facilities for preserving food, much illness results from food spoiled or infected by standing among unsanitary conditions. Unless cold storage is available, meat is generally cooked and eaten the same day the animal is killed. It is highly essential that meat, cooked or uncooked, be protected from flies, roaches, and other insects.

The choleraic diarrhea and other toxic symptoms, more frequently observed in the tropics than elsewhere, following the ingestion of decomposed meat, and especially that which has been insufficiently preserved, are due to infective organisms of the coli group and their toxins. The best known of these are *Bacillus enteritidis, Bacillus enteritidis sporogenes* and *Bacillus botulinus*. Many cases of ptomaine poisoning follow the consumption of decomposed fish. Prawns and mussels at times give rise to severe toxic symptoms. There is good authority for the statement that fish transmit cholera, and that oysters have transmitted it in India. Oysters are also credited with being responsible for cases of typhoid fever in the tropics. Fish may contain the cysticerci of *Dibothriocephalus latus,* and meat the cysticerci of *Tænia saginatta and Tænia solium.* It is obvious that neither should be eaten unless well cooked.

Chapter XIX

SANITARY MEASURES FOLLOWING GREAT DISASTERS

General. It is a matter of history that disease and pestilence are prone to follow in the wake of great disasters such as floods, fires, tornadoes, earthquakes, and volcanic eruptions. This is due the destruction or temporary abandonment of habitations and the necessarily close association of considerable numbers of people in places of refuge such as camps, with the attendant exposures to and opportunities for the spread of communicable diseases among them; to the insanitary conditions arising from the incapacitation of sewage and water systems; to the inability to dispose properly of organic excreta, refuse, dead animals, etc.; and to the lack of adequate and pure food and drinking-water.

There are many potential dangers to be considered in such emergencies, and it is imperative that they be recognized early in order that proper precautions be taken to prevent their occurrence. An unchecked epidemic might prove more disastrous to human life than the original catastrophe. The prompt discovery and enforcement of proper precautionary measures for cases of communicable diseases, important at all times, is especially necessary in the disturbed period following great disasters. Military discipline is necessary to cope with the unusual and atypical problems tending to break down the health of a stricken community. To act as if the common sanitary standards of maintaining health in a community will answer the purpose at such times is to fail to grasp the situation with all its dangers. Too strict sanitation is scarcely possible. The highest practicable civilian standard is in keeping with the military standard.

For the maintenance of order and to facilitate the reestablishment of normal conditions, martial law should be declared, or the State and national military forces should be placed at the disposal of the local authorities. The latter was done at the time of the San Francisco fire in 1906. Authority in sanitary matters should be vested in the local health officers in case of catastrophes involving cities, and in State officials when larger districts are involved. In either case Federal, State and local health officers must coöperate. It may be advisable to entrust the supreme direction of sanitary affairs to a Federal officer. This was done at Dayton, Ohio, during and after the flood in 1913.

The care of refugees is the greatest problem confronting the authorities after a disaster of the first magnitude. The basic principles governing this are the same, irrespective of the nature of the catastrophe. The refugees must be gathered in places of safety under the best sanitary conditions the circumstances permit, and the sick, especially cases of communicable diseases, cared for and, if necessary, isolated in hospitals. Experience has shown that the establishment of refugee camps under military discipline is the best means of accomplishing this end. Among the first efforts in rehabilitating a stricken city should be the repair and rebuilding of hospitals.

Refugee Camps. When crowding, confusion, and disorder prevail, the paths of infection are apt to be unusually numerous and direct, therefore in refugee camps the number of people should be as small as possible and the accommodations unusually ample and orderly.

Whenever possible, in selecting a site for an encampment, due regard should be given to character of soil, topography, accessibility, availability of water supply and sewage, and general sanitary conditions in the neighborhood. Gravelly or sandy soils are preferable to clayey ones. The gentle slope of a hill is desirable, as it affords good natural drainage. Labor and expense are spared if the camp can be established near supply stations.

Arrangements should immediately be made to furnish a safe water supply, and when practicable the city supply should be piped to the camps. Open wells and springs near civilian encampments are very liable to contamination. Private wells should not be allowed in camps. The sources of supply should be as few in number as possible, but the quantity of water should be abundant. If the quality of the water that must be used is questionable, it must be treated under supervision of the camp authorities by boiling or with hypochlorite of lime. The Waterhouse-Forbes sterilizer, United States Army type, is well adapted for this purpose.

So far as practicable, camp sites should be selected with a view to having connections with the city sewage system, never placing them in grossly insanitary parts of a city, especially if unsewered. If the water-carriage sewage system is available and sanitary water-closets can be installed, one of the greatest difficulties of camp sanitation will be overcome. The camps in Oakland, California, for the refugees from the San Francisco fire, were immediately connected with the main city sewers.

Camps must be provided with adequate toilet facilities, or the refugees will pollute the ground or use toilets outside the encampment which may have been damaged and made unfit for use, as was the case in San Francisco as a result of the earthquake that preceded the fire. In Oakland at that time separate toilets for men and women were erected over manholes in the center of the streets on every block in the congested portions of the city. If a water-carriage system is not available for the camps, sanitary privies provided with water-tight receptacles for the excreta, and so constructed that their contents will not be accessible to flies, should be provided. A good disinfectant, such as chloride of lime, 1 pound to 8 gallons of water, should be used on the excreta. When the receptacles become two-thirds full their contents should be removed in a cleanly way, carried to a proper place without the camp, and buried or burned. No cesspools or slop latrines should be dug in the city or camp.

In the maintenance of sanitary conditions in a camp no other measure is so important as the proper collection and disposal of human excreta. For the proper care of the privies an adequate scavenger service should be provided and its work carefully supervised. The importance of preventing the dissemination of human excreta in a camp much more than justifies the labor and expense of construction of sanitary devices, even under the trying circumstances attendant upon the establishment of a camp for refugees.

In temporary camps presenting certain favorable conditions in respect of soil formation, topography, and ground water, there may be used with a reasonable degree of safety, deep, narrow trenches in the ground instead of water-tight receptacles for the excreta. If this system is adopted, careful regard must be given to the possibility of causing pollution of water supplies, such as wells and springs, in the neighborhood. The contents of the trenches should be thoroughly protected against fly invasion by having screened houses or seats over the trenches. Details of the construction and care of latrines of various types are given in the section on Military Sanitation, to which the reader is referred.

Garbage and other refuse should be collected in fly-proof and water-tight receptacles, removed daily, and properly disposed of by burning, burial, or dumping into the sea. The municipal crematory was damaged by the San Francisco earthquake, but the garbage and other refuse from the unburned districts and from the camps was towed out to sea in barges and dumped. Excreta and garbage that are necessarily exposed may be sprinkled with Paris green solution to prevent fly breeding, or with coal oil to repel the insects.

In permanent camps other aids to municipal sanitation, such as underground drainage, in addition to water and sewage systems, may be installed.

Tents for use in refugee camps are generally obtainable in ample numbers from the Federal and State military authorities. A trench should be dug around each tent to prevent flooding by rains. They should, if practicable, be floored and not overcrowded.

The refugees in the camps should be encouraged to eat only cooked food. All milk used in the camps should be pasteurized. All food supplies should be inspected.

Camps must be kept thoroughly clean. The sanitary police and administration must be under civil or military officials who are continuously at the camp and who are responsible to the authorities.

Active warfare must be waged against flies and other insects, and the general use of mosquito nets should be encouraged.

Refugees are ignorant and careless in regard to the disposal of excretions and of other hygienic and sanitary matters. The camp medical officers should instruct them in sanitary requirements by means of lectures, hand-bills, etc. Frequent inspections should be made of the tents and their immediate surroundings, and all sanitary errors and indiscretions corrected and prevented.

All persons entering a camp as refugees should be inspected upon admission and daily while there. By this means cases of communicable disease may be detected early, and the necessary precautions taken to prevent the dissemination of the infection. As soon as discovered cases of communicable diseases must be isolated in tents. Contacts must be followed up.

The injured and non-infectious sick should be provided for in special camp hospitals.

Certain general sanitary measures are indicated after every disaster of whatever nature. They are as follows:

1. Reëstablishment of water supply.
2. Reëstablishment of sanitary conveniences.
3. Removal of putrescible matters.
4. Removal of débris and cleaning of streets.
5. Cleaning of buildings, houses, and yards.
6. Anti-insect campaigns.
7. Sanitary inspection.
8. Separation of persons with communicable diseases.
9. Specific immunization.
10. Disinfection.
11. Promulgation of sanitary regulations.
12. Establishment of chemical and bacteriological laboratories.

1. **Reëstablishment of Water Supply.** If the public supply is available steps must be taken at once to insure its safety and distribution. If the public supply is impaired, or there is the slightest doubt as to its safety, a rule should immediately be put in force to boil all water used for drinking purposes. If fuel cannot be obtained, the authorities must distribute a supply of water of assured sanitary quality by tank-wagons, barrels, or otherwise. If the public supply is readily accessible and known to be safe, the inhabitants are not so apt to use water from underground cisterns, shallow wells, and other sources such as flood water, which is liable to be dangerously contaminated.

In sanitary emergencies the treatment of water with hypochlorite of lime is a ready means of securing a safe water supply. The cost of the treatment is reasonable. For the majority of water supplies only about 8 pounds of "chloride of lime" are required for each million gallons of water. The apparatus for applying the treatment is simple, and may be installed in a few hours. The solution of lime may be applied as the water enters or leaves a reservoir or as it flows through a main or conduit.

The solution should be applied as the water flows through some place at a known rate, so that the proper amount will become mixed with a known volume of water. The water supply of a city of 5000 to 20,000 may be treated with a very simple emergency apparatus, consisting of three ordinary barrels of 50 gallons' capacity and a little piping, one of the barrels to be used as a mixing tank and the other two as distributing tanks. The hypochlorite solution should not be relied upon to disinfect waters which are highly turbid. A water having a high turbidity should be subjected to some clarification process, such as coagulation, sedimentation, or mechanical filtration, or some combination of these, before having the hypochlorite treatment applied.

The water supply may be quickly made safe by the addition of chlorine directly from cylinders by means of a regulating apparatus as described in the chapter on "General Prophylaxis." When the cylinders are available this should be the method of choice.

Water in cisterns, if clear or nearly so, may be treated effectively with hypochlorite of lime. To treat 5000 gallons in tank or cistern proceed as follows: Put 1 ounce of good hypochlorite of lime (containing at least 30 per cent of available chlorine) in a vessel containing about 2 gallons of water; shake or stir rapidly for about a minute; let vessel set for about five minutes so that most of the insoluble part of the lime will settle to the bottom; pour the solution into the cistern and by some mechanical means agitate the water so that the solution will be quickly diffused throughout the volume of water.

Water on a still smaller scale—by the bucketful in a private home, for instance—may be treated by the hypochlorite process. Add 1 teaspoonful of good hypochlorite of lime to 1 pint of water and keep the solution in a tightly stoppered bottle; add 1 teaspoonful of this solution to 2 gallons of water to be used for drinking and stir quickly. Let water so treated stand for fifteen to thirty minutes before being used. The stronger solution used in the treatment of water on this small scale is to afford a liberal margin of safety.

Bottles of the hypochlorite solution may be put up and properly labeled at central stations, and distributed to private homes not having access to entirely safe water supplies. The application of this method of treatment in the private home, while perhaps not furnishing as absolute a safeguard as boiling the water would, has proved to be feasible in some flood-stricken towns. Many people who cannot or will not go through the troublesome task of boiling all water for drinking will use the hypochlorite method.

People should be warned against using untreated water from polluted wells and cisterns. When safer water supplies are available no water from shallow (dug) wells and contaminated cisterns should be used. Such cisterns should be pumped out, disinfected with hypochlorite of lime solution (1 pound to 8 gallons of water) and refilled from subsequent rains. Shallow wells, polluted or obviously exposed to dangerous pollution, should, whenever feasible, be abolished permanently by official action. (L. S. Lumsden, "Sanitation of Flood-Stricken Towns and Cities.")

The water supply of a small stricken community may be amplified by distilled water from ships. The U. S. revenue cutter *Manning* furnished water from her evaporaters to the villages of Kodiak and Wood Island, Alaska, during the volcanic eruption of Mount Katmai on Shelikof Strait in June, 1912.

The vigilance of the sanitary authorities is required not only to prevent people from drinking contaminated water as such, but to prevent its use in the manufacture of soft drinks sold at refreshment booths. This occurred in San Francisco after the fire, but it was promptly detected and stopped.

2. **Reëstablishment of Sanitary Conveniences.** When sewers are available and can be used, temporary closets can be built over manholes in the streets. When the sewers are available but cannot be used on account of damaged toilet fixtures or impaired water supply, water-tight, covered receptacles should be provided to be used until other provision can be made. These are to be emptied into the nearest sewer or vault at the direction of the sanitary authorities.

When the sewage and water systems are made useless, as by the earthquake at San Francisco, the use of earth latrines becomes a necessity. They are very difficult to maintain in a healthful condition. As lumber and labor become available, more elaborate houses should be built over the trenches, and screened to keep out the flies.

A sufficient number of latrines must be maintained not only to prevent the depositing of night soil in any other place, but to provide sanitary conveniences for workmen engaged in reconstruction work in parts of the city with no sewer connections.

3. **Removal of Putrescible Matters.** Fecal matter, dead animals, garbage, and other putrescible wastes should be immediately removed, in wagons, if possible, and properly disposed of. Fecal matter and other semifluid wastes may be discharged into existing sewers, but dead animals should be incinerated. A scavenger system must be immediately instituted. Attempts to incinerate garbage when sanitary reduction works are not available do not meet with success. The crematories and incinerators described in the section on "Military Sanitation" may be used to advantage. Instructions must be given to householders to place their garbage barrels at the curb, whence they should be emptied and the contents removed without cost to the citizens. Carelessness in the disposal of garbage engenders carelessness in more important sanitary matters. If an adequate and reliable system

of collection be provided, little difficulty will be experienced in inducing people to place garbage in proper places.

The bodies of the dead must be promptly removed and properly disposed of by burial or cremation. Temporary mortuaries must be improvised in which relatives and friends may identify and claim their dead. The chief danger of epidemics after disasters is not from dead bodies, but from infected persons among the survivors, and the tramps, adventurers, and others who flock to scenes of catastrophes to get in line with the relief funds.

4. **Removal of Débris and Cleaning of Streets.** Gross *débris*, such as wrecked and burned buildings, uprooted trees, and the general litter scattered by tornadoes and floods must, of course, be removed in wagons or trucks. If the water supply is available the mud left by floods may be washed away; if not, it must be removed by scraping or brooming. Whatever the nature of the dirt and *débris,* the stricken city or community must have a thorough cleaning and be kept clean until living conditions again become normal.

5. **Cleaning of Buildings, Houses and Yards.** This phase of sanitation is of more importance after floods than any other disaster, and will be discussed under that subheading.

6. **Anti-Insect Campaigns.** Measures to prevent the dissemination of typhoid fever and dysentery by flies are important. People must be made to understand the necessity of screening foodstuffs and of placing fly-traps in homes, bakeries, restaurants, and in all places where food is sold or kept. Stables must be screened and manure protected from flies. All organic matter, such as the bodies of dead animals, human excreta, etc., in which flies may breed, must be promptly removed. In the refugee camps in and around San Francisco small sulphur candles were successfully used in the tents for killing flies.

Mosquitoes are apt to be troublesome after floods. The accepted measures of screening and the elimination of their breeding places by drainage, oiling of small bodies of water, etc., must be enforced. Disease-bearing mosquitoes must be especially watched for and active measures taken against them.

7. **Sanitary Inspection.** A corps of sanitary inspectors should be immediately organized. Women physicians and nurses are well adapted for this work, and especially to giving instruction in sanitary matters. The stricken city or district should be divided into several sections, with a skilled santarian at the head of each section, who should be held responsible for the careful sanitary inspection of his territory. House to house inspections must be made to manage and control the disposition of refuse, the cleansing and disinfection of yards and houses, the detection of communicable disease, the delivery of sanitary supplies, etc. The inspectors frequently discover cases of non-communicable diseases that are in serious need of care and medical attention. They should instruct householders as to how food should be protected from flies, dust, and contamination by the hands of sick persons and their attendants.

The sanitary authorities must enforce a vigorous inspection of the food supply. After the San Francisco disaster it was necessary to condemn great quantities of meat, fish, vegetables, and fruit as unfit for food. Special vigilance must be maintained over the milk supply, a problem made worse by the lack of milk containers, such as milk bottles. Milk from insanitary dairies should be excluded; that supplied to refugee camps should be pasteurized. Citizens remaining in their homes should be advised to boil the milk.

8. **Separation of Persons with Communicable Diseases.** There are always some of the communicable diseases among large numbers of people. The known cases existing previous to the disaster should be removed to special improvised hospitals, generally tents, at the earliest possible moment—not only cases of acute disease, but pulmonary tuberculosis also.

Precautionary measures about the bedsides of communicable cases treated in homes should be carried out under official supervision, and visiting nurses should be provided to assist in this work.

The house-to-house inspection of the sanitary inspectors and the daily examination of the refugees will detect many cases, all of which must be reported at once, and special efforts made by all physicians to make early diagnoses and to detect mild and atypical cases, as well as to follow up contacts.

An epidemiological map of the stricken area should be prepared daily. Every communicable disease should be investigated, including in addition to the usual notifiable diseases, diarrhea, tonsillitis, sore throat, acute bronchitis, bronchopneumonia, and lobar pneumonia. Complete and systematic records should be kept for statistical purposes.

9. **Specific Immunization.** If smallpox is present among the inhabitants of the afflicted district the people generally who are not already protected by vaccination, especially those in the refugee camps and congested sections, should be vaccinated as promptly as possible. The objection that sore arms may interfere with the very necessary performance of manual labor is more than offset by the special danger of spread of the infection, as a result of the unusually close association of large numbers of people.

Antityphoid inoculation should be made available and its general use strongly urged. It does not seem advisable to undertake compulsory antityphoid inoculation in a civilian community.

Smallpox vaccine and antityphoid serum should be supplied by the State health department.

10. **Disinfection.** A disinfecting crew provided with teams carrying disinfectants and deodorants in tanks with force pumps and hose for spraying them, if necessary or practicable, and possibly appliances for digging latrines, should

be under the orders of the sanitary inspector of each section. Their activities are influenced by the nature of the disaster, the amount of damage done, and other local conditions.

Among the suitable disinfectants are: Hypochlorite of lime solution, made by adding 1 pound of the chemical to 8 gallons of water; quicklime solution, made by adding 10 pounds of good unslaked lime to 10 gallons of water. Bichloride of mercury solution, 1/1000, is useful for the hands and clothes. Permanganate of potassium and carbolic acid have been used in the past, but are now too expensive for general use.

After disasters of whatever nature many privies and cesspools are in a highly insanitary condition and should be disinfected at once under official supervision. The houses over many privy pits and cesspools may have been washed, blown, or burned away, and the areas around them, as in alleys and yards, overflowed and heavily polluted. If the houses remain they are probably befouled and polluted. As a general sanitary measure all insanitary privies and cesspools and the pits from over which the houses have been carried and burned away should be disinfected.

Disinfecting crews with wagons carrying disinfectants and mixing tubs or tanks should cover systematically the sections of the stricken area in which there are privies or cesspools. Each privy should be treated with 8 to 10 gallons of the hypochlorite of lime solution or quicklime solution, the disinfectant being applied liberally to the woodwork and to the pit under the seat. The polluted areas around the privies and cesspools should be soaked with the solution. This systematic disinfection should be repeated once every week or ten days until the faulty sanitary conditions have been permanently corrected or have at least reverted to their normal.

The doors and ventilators of latrines should be disinfected frequently.

At San Francisco 5 per cent crude carbolic acid solution was sprayed on the surface soil through the refugee camps.

The disinfecting crews should be employed to disinfect and fumigate bakeries, baths, and laundries, and to spray pools of stagnant water with coal oil to prevent the breeding of mosquitoes.

11. **Promulgation of Sanitary Regulations.** The health authorities should issue bulletins in several languages containing and explaining sanitary regulations. It must be demonstrated to the people that there is nothing personal about the orders and requirements of the sanitary authorities. These bulletins should contain: (*a*) Instructions as to cleansing of premises; (*b*) Sanitary care of household effects, such as bedding and cooking utensils; (*c*) Disposal of garbage and other wastes; (*d*) Methods of using disinfectants and deodorants properly. These directions should be especially clear and brief, but sufficient, as there is much popular misinformation on the subject; (*e*) Need of proper precautions in the matter of diet; (*f*) Value and importance of antityphoid inoculation and grave danger of rapid spread of typhoid fever. It may be advisable to issue this as a special leaflet.

12. **Establishment of Chemical and Bacteriological Laboratories.** As soon as possible laboratories should be established, or those of existing educational and scientific institutions utilized. No scientific public health work can be carried on without a laboratory in which samples of food, water, and milk may be examined to supplement inspections in guarding against contamination. Here also specimens of blood, urine, sputum, and other pathological matters can be analyzed.

Floods

Floods, besides causing destruction of life and property, always give rise to well-grounded apprehension of epidemics of communicable diseases, especially typhoid fever. The crowding together of practically destitute people in places of refuge and the difficulty of preparing and serving food in a cleanly manner strongly predispose a community to the spread of disease by contact and by contaminated food. To this may be added the dangers due to a polluted and impaired public and private water supply. The pumping stations and purification plants may be incapacitated; wells and cisterns may be overflowed and contaminated with flood water which contains much potentially dangerous matter. Under such conditions people are apt to drink almost any accessible water, including the filthy flood water in the streets. Naturally the danger from water-borne infections is tremendously increased. With time, labor, and fuel at a premium, it is exceedingly difficult to make people heed the warnings concerning the water used for drinking.

The rising waters may back sewage up into basements and houses by interfering with the discharge from the sewers; cesspools and privy vaults may be overflowed and their contents washed around, even into houses, thus disseminating fecal-borne infections. When towns are covered with water to a considerable depth, the sewage and contents of the cesspools and privy vaults are tremendously diluted, and are carried away as the flood water flows through or gradually recedes from the town. Some filthy country towns, immediately after a flood, find themselves in better sanitary condition in regard to the dissemination of human excreta than they were before the disaster.

Insanitary privies and cesspools are particularly dangerous to the health of a flooded town or district. The greatest danger is not from those that are under water or have been washed away, but from those that are in use during and after the flood. A flooded town may be unsewered or partially so and many houses in the sewered part may have no sewer connections. During the high water insanitary privies in the more elevated part of the town are used by persons whose homes are under water or carried away. This severely overtaxes the already insanitary privies and they become unspeakably filthy. When flooded, non-sewered parts of the town are again occupied by the inhabitants, the scarcity of serviceable sanitary conveniences due to many privies having been overturned or carried away by the flood leads to overtaxing the remaining privies and to promiscuous pollution of the soil.

Such sanitary conditions existing in the late summer or early autumn would almost certainly lead to outbreaks of typhoid fever and other fecal-borne infections.

Floods always leave débris, mud, carcasses of dead animals, and a certain amount of sewage and the contents of cesspools in the streets, alleys, and yards of a town as the water recedes. This condition, of course, is highly objectionable, but its importance from a sanitary standpoint is placed by the laity above conditions pertaining to the water supply and the disposal of human excreta. The latter, however, are a much greater menace to the health of the community.

Receding floods leave houses damp and soiled with mud. Basements and cellars may remain full of water long after it has left the streets, thus rendering useless heating apparatus which may be located in basements, and perhaps making it impossible to heat any part of a house for lack of stoves or grates. If they are available there may be little or no fuel. People naturally try to keep warm by keeping the doors of bedrooms and living rooms closed. Living and sleeping under such conditions, probably in damp clothing, leads to an increase in diseases of the respiratory tract.

Towns having complete and properly installed water-carriage sewage systems present sanitary situations of the least gravity after floods. Any damage to the system caused by the high water should be repaired as promptly as possible. The sewage system generally returns to its normal condition as the flood recedes. Much trouble is caused in small towns and cities by the incompleteness of the sewage systems. Additional privies of a sanitary type should be installed in temporarily congested non-sewered districts, and the inspectors should see that they are kept in a sanitary condition. An adequate scavenger service should be maintained to dispose of night soil in a sanitary way. When the stricken districts are again occupied by the inhabitants after the recession of the flood, it may be advisable to install a certain number of public convenience stations in those districts to prevent overtaxing the existing sanitary arrangements, while proper toilet facilities in homes should be among the first things to receive attention in the work of rehabilitation. Privies washed away by the high water should be replaced by sanitary ones and those overturned or damaged should be repaired and improved.

A sufficient number of teams and laborers should be provided for the proper removal and disposal of *débris,* mud, and dead animals from streets, alleys, yards, and houses. The work should begin as the water begins to recede, as much of the mud may be shoveled or scraped into the receding flood and carried away by the current. Some of the débris may be useful as firewood or for other purposes, and that which is useless should be removed to suitable places and burned. Dead animals should be cremated or buried. Mud in streets, alleys, and yards should either be washed away with flushing hose by the fire department or scraped into piles and hauled away.

The promiscuous sprinkling of streets and yards with air-slaked lime is of little or no value, and may give a false sense of security. If the streets and yards are mechanically clean, sunshine and air will quickly disinfect them.

The people generally should be instructed by the health authorities through the local press, public addresses, etc., as to the importance of having flooded homes in good sanitary condition before reoccupying them. Basements and cellars should be pumped out; mud should be scraped and washed out, and after the portions of the houses which have been flooded have been rendered mechanically clean, the floors and walls should be washed with a disinfectant solution such as hypochlorite of lime, 1 pound to 8 gallons of water. After being cleaned houses should be sunned as much as possible, aired by keeping windows and doors open, and when practicable, dried by keeping open fires going. Houses should not be reoccupied until reasonably dry. People are better off in a well-managed camp than in damp, poorly heated, and poorly ventilated houses.

After the floods in the valley of the Seine in 1910 the wholesale disinfection and general rehabilitation of all inundated properties was undertaken by private organizations and by state authority. The access of so much water into cellars and basements would probably have predisposed the inhabitants of the flooded houses to much influenza, tonsillitis, rheumatism, pneumonia, pleurisy, bronchitis, etc., but for the energetic and efficient methods used in meeting the untoward conditions.

It is well that houses should be inspected by a sanitary inspector and permits received from the health department before they are reoccupied.

During and after the floods in the valley of the Ohio and its tributaries in 1913 a sanitary survey was made by boat under the command of an Army officer. Instructions by word of mouth and by printed matter were spread among the people of the flooded districts covering the following points: The cleaning of houses—scouring of mud off of floors and walls; scrubbing of walls and floors with disinfectants; disinfection of cellars, outhouses, surface soil, etc.; removal of mud and filth from streets—suggestions as to its use as fertilizer.

The work of sanitation made necessary by flood conditions may bring municipal authorities and the people generally to a realization of insanitary conditions that existed before the flood, and which urgently require permanent improvement. The public water supply may have been exposed to dangerous pollution and efficient purification processes may have been lacking; the sewage system may have been inadequate; grossly insanitary privies and cesspools may have been numerous in thickly populated districts; the collection and disposal of stable manure, garbage, and other refuse may have been inadequate and faulty; sanitary inspection, including food inspection, may have been insufficient, and the local health board may have been undermanned and lacking in funds for efficient service. Federal and State medical officers and officials should grasp the opportunities afforded by sanitary emergencies to impress upon stricken municipalities the gravity of their sanitary shortcomings. (Lumsden.)

Fires

After all large fires, whether city or forest, numbers of people will require food, clothing, and shelter, and this must be provided by local, State, or Federal authorities or by the Red Cross, according to the extent of the conflagration. The strictly sanitary problems present nothing characteristic. The measures heretofore enumerated for preventing the spread of communicable diseases among closely crowded refugees must be strictly enforced. In city-wide conflagrations such as the San Francisco fire, refugee camps must be established; in those of relatively limited extent, such as the Chelsea fire, the refugees may be housed in public buildings such as State armories, in which case the following points require attention:

Precautions against fire; separate sleeping quarters for the men and women; separate toilets; feeding; prevention of disease.

The first four points are of more interest from an administrative than from a sanitary standpoint, and the details must necessarily be governed by the local conditions, type, and size of buildings, etc. The State military authorities should be in charge of the situation, and the medical department should oversee the sanitary administration of the buildings housing the refugees. This plan was very successful after the Chelsea fire in 1908.

As people arrive they should, if possible, be placed in a quarantine room near the entrance of the building and examined by the surgeons. The throat, eyes, scalp, and skin should be especially observed. As many of the refugees will be from the lower walks of life, much filth and vermin will be found. Immediate bathing and treatment are indicated. The adult Chelsea refugees were sent to the city baths, and the children were bathed at the armory. Every morning the children under fifteen were stripped to the waist and examined thoroughly by the surgeons, and those found afflicted were set aside for treatment.

The food and kitchens should be inspected twice daily by the medical officers. The main rooms of the building should be sprinkled with wet sawdust and swept daily, the living quarters being sprinkled with a solution of sulpho-naphthol and swept several times a day as a precaution against vermin. The sweeping should be done by male refugees under the direction of hospital corps men. Barrels should be placed conveniently for refuse and labeled in the languages of the refugees.

This mode of caring for refugees is applicable to many emergencies, but has been used most frequently after fires.

If people live in shacks built from the remains of the fire, their habits cannot be kept under strict sanitary supervision. Shacks, as a rule, are unfit for human habitation.

After forest fires immediate steps must be taken by the State authorities and the Red Cross to aid the sufferers to rebuild their houses, barns, etc. After the Minnesota forest fires of 1910 hundreds of cheap but serviceable huts were built on the burned farms and in the devastated villages.

Many ruined and polluted wells and cisterns must be filled and insanitary cesspools and privy vaults filled or destroyed.

New ones should be constructed only under sanitary supervision.

The burned districts must be patrolled and both human and animal dead bodies buried or cremated.

The State sanitary authorities must keep a close scrutiny for typhoid suspects and encourage antityphoid inoculation.

Tornadoes

Tornadoes, hurricanes, or typhoons, as they are known in different parts of the world, cause the greatest loss of life and property in the shortest space of time of any of the great forces of nature. Hundreds of thousands may be made absolutely destitute, as by the hurricane in Porto Rico in 1899, and tens of thousands may be killed, as was the case during the great typhoon at Hong Kong in 1906. Seafaring populations are especially liable to immense losses of life by such storms. Tornadoes may be followed by floods, or the wrecked towns may be burned. Not only are habitations destroyed, but the actual and potential food supplies may be ruined or cut off by the destruction of warehouses, standing crops, and fishing boats. The water supply may be impaired by the destruction or damage to public waterworks, the destruction of tanks and cisterns and the pollution of wells and water courses. Sewage systems may be choked or otherwise damaged, and cesspools and privy vaults flooded.

If cities or towns are stricken, refugee camps must be established. In rural districts the greatest good may be accomplished by aiding the inhabitants to rebuild their homes immediately and by supplying them with seeds and domestic animals. In all cases it is necessary to feed the population for a greater or less length of time. As their personal effects have in most cases been destroyed or hopelessly lost, large supplies of clothing must be furnished. Victims of hurricanes have less chance to save their belongings, such as clothing, than have the inhabitants of flooded or burned cities.

The measures necessary to restore the water supply, to reestablish sanitary conveniences, to separate cases of communicable diseases, etc., differ in no way from those described under general measures.

Earthquakes

Earthquakes not only of themselves cause great loss of life and property, but they may be followed by a tidal wave, as was the great earthquake at Lisbon in 1755, or by destructive fires, as at San Francisco. Buildings may be actually leveled, killing the inhabitants, or may be rendered almost if not quite uninhabitable. At San Francisco the reservoirs of the municipal water works were cracked and a great deal of the water escaped. The water mains were broken and the fire-fighting apparatus thus rendered useless. The sewers were broken, and this together with the lack of water rendered the sanitary arrangements worse than useless. The chimneys of houses were damaged, thus making the proper preparation of food by cooking difficult. An earthquake unaccompanied by flood or fire in a rural district does not cause as serious a sanitary emergency as one affecting a city equipped with a public water supply and sewage system.

A safe water must be immediately supplied in tanks, barrels, etc., to householders and refugee camps. Latrines must be built and their sanitary safety insured by official supervision and disinfection.

There is great danger of typhoid fever being spread by flies, as the cooking must be done in the streets on account of the damaged chimneys. Very careful instruction must be given to the people as to the protection of food supplies and waste of all kinds from flies. In San Francisco the rapid rise of the typhoid rate was partly due to fly-borne infection, partly to infection of food at camp kitchens and partly to contact infection.

A house to house inspection should be made by plumbers to shut off the water when the pipes are broken, seal the toilets, make temporary repairs, and stop leaks.

Volcanic Eruptions

After some of the historic volcanic eruptions no sanitary measures were indicated; the cities were destroyed and the inhabitants dead and buried under the ruins and lava. Such was the case at Saint Pierre, Martinique, in 1902. If the people or any part of them survive as refugees, they must be removed by ship or otherwise, and their health and protection assured by the means already described.

Chapter XX

SANITARY ADMINISTRATION

"The supervision of the public health is based on the general police power of the State, using both terms in their broadest sense. That power involves the right of the State to regulate the conduct of citizens in such a way that their acts or omissions do not materially and unreasonably injure other citizens. As society grows more complex the exercise of that power involves more extended functions. Most of these are prohibitive in character, though some of the auxiliary functions, such as publicity work and the establishment of dispensaries and hospitals, are constructive. The latter have been fostered by the growing coöperation of health departments with organized charities and other social service organizations.

"The sovereign power of the state, as expressed through legislature, delegates sanitary functions to certain official bodies and individuals—commonly to boards of health—who thus obtain their power through statute law. That law is presumed to represent the kind and degree of authority which the people at any time desire to confer on their servants in sanitary administration. It is necessarily granted in general terms which are subject to interpretation by the courts." (McNutt.)

Sanitary authorities have always been vested with powers of rather a sweeping character, which were from the beginning based upon fear in the face of epidemic disease. In the past these arbitrary and summary powers have conferred on them the right to deprive persons of liberty and property, to check wholly or partly commercial operations, and to disturb civic life to any extent deemed necessary to avert menaces to public health. Their acts have usually been sustained by the courts if there was any reasonable ground for the exercise of such autocratic functions. As sanitary science becomes more exact there is a tendency to define the powers of health authorities more exactly, and to confine them within closer limits. In most instances these functions have been curtailed, but occasionally they have been extended. Sanitary laws are much more specific than formerly, and are more mandatory than permissive. Blanket powers are no longer conferred; the duties of health authorities are carefully defined, and come nearer to coinciding with their powers. Nevertheless the public health laws, as interpreted by the courts, are usually capable of flexible application, as a certain degree of discretion must be allowed the sanitary authorities in order to cope successfully with unforeseen emergencies.

Local Health Authorities. Local sanitary authority is usually vested in a board of health. In some small communities this authority is exercised by the local governing body, such as the township committee or the board of selectmen. Except in small towns and primitive communities, boards of health entrust their executive work to an official variously styled "health officer," "health inspector," "health commissioner," "superintendent of health." This official may be a physician in active practice who devotes part of his time to public sanitary work, or he may be a physician, sanitary engineer, or trained sanitarian educated in public health work. According to the size and progressive spirit of the community, the health officer may have to perform all the duties of the office, or he may be assisted by a staff of sanitary inspectors, clerks, and other employees. He attends to routine administrative matters and takes such executive action as he may be empowered to take by the board. The fundamental authority and responsibility reside in the board, which retains a general directive power, decides important questions of administrative policy and procedure, makes sanitary regulations, and prescribes the general manner of their enforcement. The health officer, staff, and the board of health constitute the health department, or health authorities.

The expert health officer, with his staff, is the most important factor in public health administration. He, and not the board, has the technical knowledge of sanitary principles and conditions; it is he who initiates and carries out the measures necessary for the preservation of the health of the community. The board of health acts as mediator between the public and the health officer. It should be competent to deal with sanitary, social, and economic questions in their broadest sense, as such questions are in their final decision nontechnical in nature. In rural districts, where a State or county code can be drawn up for large areas, it is doubtless best that local boards of health be abolished and that the health officer be made accountable to expert State or county authority. But in towns and cities, which have a greater degree of civic individuality, the board seems likely, for the present at least, to remain. It acts as a check on the health officer, preventing him from putting impracticable schemes into effect, but at the same time giving him the backing of its prestige in difficult cases. (McNutt.)

As boards of health are not expert bodies, its members need simply be intelligent citizens of sound judgment. Most, if not all, of the expert advice should be furnished by the health officer. The board should not be composed exclusively of physicians. It is well, however, to have the medical profession represented by one member at least, particularly if the health officer himself is not a physician. It is also desirable that one member be a sanitary engineer, to aid in the solution of such problems as water supply, drainage, etc. Boards of health should be as small as possible, preferably not over five members, larger boards being unwieldy and ineffective.

The health officer should not be a member of the board, as he would then be placed in the position of passing upon his own acts and proposals. Boards should have full executive powers, and not be limited to merely advisory and legislative functions.

Boards of health exercise their statutory powers either directly under such provisions of the statute law as directly provide for the action in question, or by means of a sanitary code adopted by themselves, based upon and amplifying in detail the general provisions of the statutes.

The sequence of procedure of boards of health in public health work is as follows: Inspections and examinations in order to determine whether or not conditions within its jurisdiction conform to the provisions of the sanitary law; deliberation as to what action, if any, is necessary in view of the conditions revealed by the inspections and examinations; and finally action which, when taken, may consist in a formal notice or a simple advice or a warning. The investigation of sanitary conditions may be carried to any extent within reason. In the performance of this duty the health authorities have the "right of entry" at proper times into and upon all premises. This may be enforced by search warrant if necessary. They have the right to examine persons in order to make diagnoses, and, if thought advisable, to keep such persons under observation. They also have the right to take and examine bacteriological specimens and to collect and examine specimens of food, drugs, etc.

In dealing with persons responsible for unsanitary conditions it is customary to accord them a hearing and an opportunity to make such statements as they may see fit before action is actually taken. The action, when taken, may consist in a formal notice, or perhaps simply warning or advice. Finally, if a remedy can be effected in no other way, legal suit may be instituted against the person responsible for the violation of the sanitary law. The board of health rarely takes arbitrary action into its own hands, and then only when an action—e. g., the abatement of a nuisance or the destruction of infected food—is urgently demanded and can be accomplished in no other way. In such instance there must be full legal power and a perfectly clear case, and action must be strictly in accordance with legal procedure. Even when disinfections are performed by the authorities, the theory is that this is merely a matter of convenience and effectiveness for private parties, who would otherwise have to attend to it themselves under official supervision. Where specific action is desired the object of the sanitary authorities is to induce that action on the part of private persons rather than to undertake the uncertain proceeding of themselves intruding into private affairs. (McNutt.)

"An *order* of the board of health (issued usually by its health officer) is a notice to the person responsible to the effect that a certain condition is contrary to a certain sanitary ordinance and directing that person to take action to avoid further violation of the law. The action ordered may be to improve a milk supply, to alter a tenement, or perhaps simply to refrain from further commission of an act detrimental to the public health. The person receiving the notice then has the option: either to comply with the order, or to disregard the order under peril of proceedings by the board. Such proceedings may consist in a suit instituted by the board to recover the penalty incurred, or, in extreme cases, the board itself through its agents remedying the condition complained of. In a dispute before the law the board and the private party have equal rights to be heard and the court will require the board to prove its case before giving judgment in its favor. The probable attitude of a court of law toward a given question should therefore always be borne in mind in the deliberations of board and health officer." (McNutt.)

In addition to maintaining an efficient inspection service and enforcing the sanitary code, health authorities have other important functions to perform, some of which are as follows: the registration of the vital records of births, marriages, and deaths; the distribution and frequently the administration of antitoxins and vaccines; research and publicity work; the maintenance of laboratories for bacteriological and serological diagnosis and for the chemical examination of food, water, etc.

State Health Authorities. State health departments are of more recent development than local health authorities, and were created to deal with sanitary problems of State-wide importance. Their functions were originally entirely advisory in character, and this is still their most important function, though in recent years they have been endowed with executive powers in order to meet exigencies of a State-wide nature. There is a tendency to increase their executive sphere of action, but at the same time to restrain them from interfering in matters which can be dealt with by local authorities, except in instances where the health of other districts than the one in question is injured or threatened. The efficiency of local boards of health would be materially increased if a greater degree of supervision were exercised over them by the State health authorities.

As to organization, most of the States have boards of health, though some, notably New York and Pennsylvania, have State commissioners of health. Boards have executive officers, usually the secretary, whose duties are analogous to those of the local health officer. The New York commissioner has the assistance of an advisory council consisting of two laymen, one sanitary engineer, and three physicians. The recently adopted plan of organization in New York State promises well for the solution of many of the most perplexing problems of rural hygiene. The State (except New York City) is divided into twenty districts, each of which is placed under the control of a "sanitary supervisor," who oversees the work of the local health officers and is himself responsible to the State Commissioner of Health. The supervisors are independent of local influence and interference; they are experts giving their full time to the work, and are subject to no local control. The most primitive country community has the benefit of the most advanced methods of public hygiene. The State Commissioner of Health, with the assistance of his Advisory Council, may promulgate a sanitary code to apply uniformly throughout the districts. The adoption of this plan shows a most wholesome tendency to centralization in sanitary administration.

State departments of health carry on laboratory, statistical, and field research and experimental work, the results of which are used in advice to local boards of health and for the information of the public through bulletins and the press.

The control of the communicable diseases is one of the most important functions of State health authorities. The advice and assistance of their trained epidemiologists are frequently of the utmost value to local health officers in connection with epidemics. The presence of these officials tends to allay public apprehension and criticism and to restore confidence in the health authorities. The state officials are in a position to recognize the danger of spread of the epidemic to other communities and to take such preventive measures as may be indicated.

Valuable service is rendered local boards and physicians in small places by the laboratories of the State health authorities. Cultures of diphtheria, etc., and samples of water and food may be sent by mail for examination. In some States diphtheria antitoxin, Pasteur treatment for rabies and other sera are furnished.

Questions of legal procedure, proposed ordinances, powers, etc., may be submitted by local counsel to State health authorities or State attorney-general for advice. The State authorities are able to render trustworthy opinions on such matters because of their familiarity with the statutory health powers and with the actual working out in practice and before the courts of the ordinances adopted by various local boards.

Some State departments arrange for periodical conferences of local health officers, at which professional papers are read and questions pertaining to public health work are discussed. Other means of raising the standard of sanitary administration are the standardization by the State authorities of methods and forms, and the devising of plans for uniform composition and reporting of certain data, especially statistical data.

The dissemination of sanitary knowledge through the newspaper press and by printed matter, such as bulletins, circulars, and posters is an important function of State health departments. The periodical bulletin not only is a factor in popular instruction, but keeps the local boards and health officers in touch with the State authorities on matters of administrative interest. Another feature of publicity work is the popular exhibit, especially the traveling tuberculosis exhibit, which is shown in different communities under the auspices of anti-tuberculosis societies, boards of health, and school boards. Exhibit-cars have been fitted up and have toured entire States, stopping in remote villages and communities seldom reached by outside influences. Their greatest usefulness is in stimulating local interest and action in anti-tuberculosis campaigns and in the movement for improved milk supplies.

The control of communicable diseases that threaten the health of more than a local community is an important function of State authorities. Acting in an executive capacity, they institute general quarantines, confiscate infected food, prohibit the pollution of water courses, etc. Probably the State control of communicable diseases on or affecting dairy premises (from which infection is easily transmitted to distant parts of the State) is their most important duty of this nature.

State pure food and drug laws are best enforced by the health authorities. Their laboratories, analysts, and inspectors well qualify them for this duty. Some States require State licenses for certain food-producing industries, such as bakeries, ice-cream and confectionery factories, etc., in which case their inspection and supervision fall under the state board of health.

A move in the right direction is the conferring by a few States on their boards of health of arbitrary powers of approval or disapproval of the water-supplies of municipalities, as based upon sanitary investigation. In Michigan the engineering division of the board has supervision of all sewer and water systems in the State, has power to deal with stream pollution, conducts investigations of water-supply and sewage, including trade wastes, and gives advice to municipalities.

In most of the States the health authorities have at least general powers of inspection and sanitary control of factories and tenements and in a few instances of the schools. The public institutions of the State, including the prisons, asylums, and hospitals, are under the sanitary supervision of the State boards of health.

It is occasionally necessary for State authorities to exercise purely local power, as, for instance, in New York State, when a municipality fails to establish a board of health, and in Indiana, where the State board of health is empowered to remove local health officers for incompetence. The correction of unsanitary conditions at summer resorts sometimes becomes the duty of State authorities.

"The usual way for State authorities to stimulate and assist local authorities is through coöperative advice, and such powers as they may hold over the latter are properly designed chiefly to insure a minimum degree of activity." (McNutt.)

Federal Health Authorities. The functions of the Federal authorities are either interstate or related to the United States as a whole and are exercised only under conditions which cannot be dealt with either by local or State authorities. The powers of the Federal Government are the most advisory and the least executive of any of the public health agencies. The various government bureaus carry on a great deal of investigation, comprising laboratory, statistical, and field work, the results of which are made public through printed reports. The facilities of the Federal Government are such that research work covering wide ranges may be carried on to the best advantage. Results are achieved that are beyond the resources of single States, while at the same time unnecessary duplication among the latter is avoided. In this work the Federal bureaus coöperate with both State and local health authorities. While as a rule the information and advice disseminated by the central government are of a general nature, it is sometimes called upon to render particular advice and assistance to State or local authorities in times of danger. Such advice and assistance was given the States of the Ohio and Mississippi Valleys after the floods in the spring of 1913 and to the city of San Francisco after the fire and earthquake in 1906.

Among the executive functions of the Federal health authorities may be mentioned the following: The sanitary supervision of interstate transportation by trains and boats; the supervision over meat and other foods, drugs, sera, and other articles carried in interstate commerce; the maintenance of the interstate and foreign quarantine systems.

Unfortunately the United States has no unified national bureau or department of health analogous to the newly organized Ministry of Health of Great Britain. The hygienic and sanitary activities of our government are distributed among various bureaus of the Treasury Department, the Department of Agriculture, the Department of Commerce, and the Department of Labor.

The Public Health Service (Treasury Department) performs many of the duties of a national board of health. It administers the national maritime quarantine service; conducts the medical inspection of immigrants; regulates the purity and potency of vaccines, antitoxins, and serums manufactured for sale in interstate traffic; and conducts investigations throughout the country on communicable diseases. It includes in these investigations sanitation and sewage and the pollution of the navigable streams and lakes of the United States. Important research work is conducted in the Hygienic Laboratory of the Public Health Service. This institution is operated in four divisions, viz., bacteriology and pathology, chemistry, zoölogy, and pharmacology. An annual conference of representatives of the State boards of health is held under the auspices of the Public Health Service, at which scientific and administrative questions are discussed and coöperation between the national and State authorities promoted.

The Public Health Reports, published weekly by the Public Health Service, for circulation among health authorities and others interested in hygiene and sanitation, contain statistical and other data relating to national quarantine, communicable diseases, and mortality throughout the country, and other related subjects. The results of the work at the Hygienic Laboratory are published in the Bulletins of the Laboratory.

The Bureau of Chemistry (Department of Agriculture) investigates the adulteration of foods, drugs, and liquors, and administers the Federal Pure Food Law.

The Dairy Division of the Bureau of Animal Industry of the Department of Agriculture conducts sanitary and economic investigations of the milk industry; the Meat Inspection Division of the same bureau and department inspects meat carried in interstate traffic and the abattoirs where it is killed and packed.

The Division of Vital Statistics of the Bureau of the Census, Department of Commerce, collects, analyzes, and publishes statistics of population, births, and deaths, for the country as a whole and for its various cities, towns, and other civil divisions.

The Children's Bureau (Department of Labor) conducts investigations and disseminates information regarding the protection and welfare of children, especially the prevention of infant mortality.

Vital Statistics. Vital statistics are the analysis and synthesis of the facts and figures concerning the life histories of communities and nations. They are the basis of scientific sanitary and sociologic work; they indicate to what extent disease and death are on the increase, and the direction in which intensive efforts should be made. This science serves as an index of the efficiency of health authorities. In order that the information derived from their study shall be trustworthy and of value, the facts and figures employed must be numerous, accurately stated, and carefully classified. The data are obtained from the census and by the system of registration.

In the United States a national census is taken every ten years, and a number of the States take a census midway between the decennial censuses; thus they have an enumeration of the population every five years. The population for the periods between the census enumerations must be estimated, the rates for the various vital events being based upon the results of the census and upon these estimates. The census gives the number of population, the races and nationalities, the number of native and foreign born, the number of sick and the nature of the disease, the deaths, births, and marriages during the census year, the sex, age, the density and overcrowding, the school, industrial, and commercial relations and conditions, marital status, literacy, blindness, and deaf-mutism, and other sanitary, economic, and financial data. No census can be absolutely accurate; there will be certain degrees of error, especially as to number of individuals, their ages and occupations. The results, however, may be regarded as being as nearly accurate as possible.

In the system of registration, reports concerning births, marriages, deaths and the causes thereof, and cases of communicable diseases, are made to local authorities, such as boards of health, and city and town clerks or registrars. The reporting of these facts is compulsory upon physicians, clergymen, and others who become cognizant of them in the course of their professional work. "In conjunction with census returns or estimates of population, they reveal the sanitary and sociological conditions obtaining from week to week, month to month, and year to year, in any community in which they are made. Through them we are enabled to watch the death rate from all causes and from any one cause, the amount of preventable disease, the probable fluctuations in population, and other facts of interest concerning communities and groups thereof. They convey information as to sanitary conditions, and suggest wherein improvement in various directions is possible." (Harrington.)

There should be a uniform and efficient system of registration throughout the whole country, but unfortunately this is not the case. The registration area comprises less than 50 per cent. of the United States, and even in the registration area it is not uniform and complete in every place. In order to remedy this condition, the Division of Vital Statistics of the United States Census Office is making extraordinary efforts to bring about uniform legislative requirements in the various States and to secure the adoption of the International Classification of Causes of Death, which has been adopted by the Census Office for the compilation of mortality statistics.

The following are the most important of the facts dealt with by the science of vital statistics: Birth rates, marriage rates, death rates, infant mortality rates, morbidity rates, mean age of death, probable duration of life, expectation of life, actual increment of population, natural increment of population.

Birth rates, marriage rates, and death rates are usually calculated as rates per thousand of the population living at the middle of the given year, and are determined by multiplying the number of births, marriages, or deaths by 1000, and dividing the product by the population. In the explanation of deaths the data given in death certificates are of very great value.

Infant mortality rates are not calculated by the number of infants' deaths per 1000 population, but are measured by the proportion of deaths of infants under one year to the births registered in that year, and are determined by multiplying the number of deaths by 1000 and dividing the product by the number of births.

Morbidity rates are calculated only as to the communicable diseases, the reporting of which is compulsory, and rated by 100,000 population.

The *mean age of death* of a population is the average age at which death occurs in that population, and is indicated by the total of the ages of death divided by the number of deaths.

The *probable duration of life* is the age at which any number of children born will be reduced one-half, the chances being even that each will survive to that age.

The *expectation of life* of a person at any age is the average number of years which persons of that age continue to live, as indicated by a life-table.

The actual *increment of population* is the difference in the number of people enumerated by the census as compared with the census taken ten years before.

The *natural increment of population* is the excess of births over deaths.

Reporting of Communicable Diseases. The reporting of communicable diseases supplies the health authorities with a powerful instrument, first, in enabling them to locate the area of the disease, to trace its origin, to watch the lines of its extension, and to gauge its progress by the knowledge which is obtained of the number of persons attacked; and second, to concert suitable measures of isolation and disinfection to prevent its extension. (Glaister.)

The duty of reporting the communicable diseases is incumbent upon physicians, persons in charge of schools (including Sunday schools), and under certain circumstances, parents, and householders. Double records should be made out for cases of plural infections. Suspected cases should be reported as such, the health department then assuming the responsibility of making the diagnosis. This is done in large cities by the diagnostician attached to the staff of the department.

The list of reportable diseases is best fixed by State law, but is sometimes, to some extent at least, left to the local boards to determine. It should include all the communicable diseases that may endanger the public health. The reporting is easily and systematically done on postal card forms. Tuberculosis should be, and frequently is, required by law to be reported under seal. Reports made over the telephone should be promptly confirmed in writing. The data concerning the communicable diseases, especially those of childhood, should be reported promptly by telephone by the health authorities, to the school authorities, infant welfare stations, public and private circulating libraries. It is well that the large milk companies be informed of the names and addresses of quarantined families on their routes. The law permitting, cases of tuberculosis should be reported to anti-tuberculosis societies.

Promptness on the part of physicians in reporting communicable diseases is essential to efficient epidemiological work by the health authorities. The trained inspectors immediately investigate the reported cases and direct their isolation if necessary. This may prevent further spread of the infection. Furthermore, early knowledge of the case may enable the health department to protect the milk and other food supplies.

Public Health Laboratories. The Laboratory of the United States Public Health Service and those of the State departments of health have been referred to in previous sections of this chapter. Every municipal board of health should have a laboratory of its own or should have easy access to one. When samples of milk and water, cultures and pathological specimens are sent to a distance, for instance to the State laboratory, the results are apt to be unsatisfactory. According to the size of the community the laboratory work may be per-

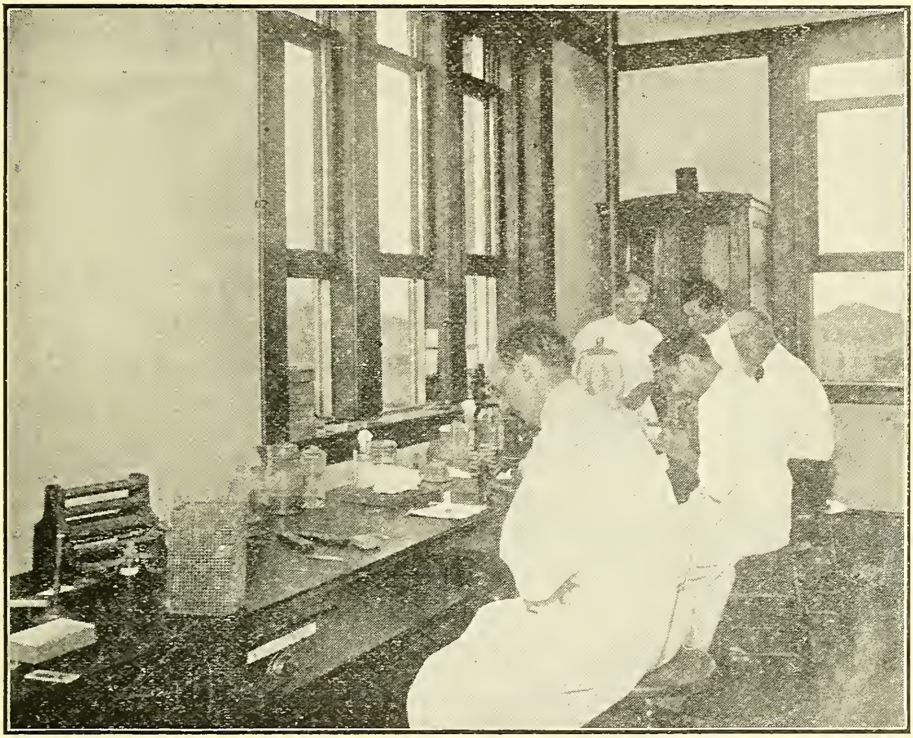


FIG. 36.—PUBLIC HEALTH BACTERIOLOGICAL LABORATORY. (*American Museum of Natural History, New York.*)

formed wholly or in part by the health officer, or it may be done under contract in some private laboratory. In towns of any considerable size a municipal bacteriologist and chemist are essential to satisfactory public health administration.

Inspection of Food. Milk is specially subject to contamination and deterioration, and is the food by which communicable diseases are most frequently spread; therefore the sanitary regulation of the milk supply is most important. Milk regulations are enforced by inspection of equipment and methods and through bacteriological and chemical laboratory tests. Milk supplies should be inspected at the dairy farm; at the bottling establishment; in transportation, whether by wagon in the country, by railroad, by wagon or otherwise in the city; and while on sale, from wagons, stores, etc.

The milk-inspection service should be a separate branch of the health department, headed by a milk inspector. Milk inspectors should preferably be graduates of agricultural colleges or dairying schools, but this is not absolutely essential. The laboratory workers must, however, have adequate technical training. The details of the sanitation of dairies, etc., are discussed in the chapter on "General Prophylaxis"; for laboratory methods the reader is referred to the special books on that subject.

The sanitary supervision of dairy farms and their personnel, transportation, country bottling, etc., should be and is in some States under the State authorities. Overlapping in the same district of the inspections of several municipalities is thus avoided, and a dairy condemned by one community cannot divert its product into another without detection. More uniform methods are secured and the spread of disease to distant parts of the State is prevented by State inspection. The local health authorities assume the supervision of the milk when brought within the limits of the local municipality, and enforce their own ordinances through coöperation with the State authorities, this coöperation taking the form of furnishing reports and evidence. The principal authority thus resides in the local health departments, whatever the relationship may be between them and the State department.

The best means of making thorough inspections of dairy farms, bottling establishments, creameries, and stores handling milk, is by the use of the score-card system. The cards of the Bureau of Animal Industry of the Department of Agriculture are used as standard. The system points out conditions to the inspector, thus making it impossible to overlook any point of importance. When it is used there is apt to be more or less competition among the dairymen for the high scores. This makes it easier for the inspector, as his suggestions are readily followed. The producer feels that he has received just treatment, as everything is a matter of record. The score-card system makes it a simple matter to establish certain inspection standards for the different grades of milk.

In the use of this system, however, it must be borne in mind that the score represents simply the general condition, and for this reason does not always indicate the importance of certain particulars which, if deficient, may assume a greater importance than would be indicated by the regular deductions from the score; nevertheless certain *specific minimum requirements* (such, for example, as to temperature) *as well as a minimum total score* should be laid down and enforced by ordinance. Under present conditions a combination of the two methods seems the most practicable. (McNutt.)

Milk standards are legally enforced by fines, revocation of permit, and by arbitrary confiscation, destruction or denaturization of the milk. Producers and dealers should be fined if the milk produced or sold by them shows two or three excessive bacterial counts. If chemical tests show the milk to be below standard they should be warned after the first tests, and prosecuted if the supply continues at fault. Subsequent offenses should incur increasing penalties. Fraudulent adulteration calls for immediate prosecution. If the products and sanitary conditions of stores or dairies remain continuously bad, the permit of the producer or dealer should be revoked, assuming that the law provides for such action. If the violation of sanitary milk standards is demonstrable on the spot the milk should be destroyed, confiscated, or denatured. This is a very drastic measure, and the inspectors must have a very strong case before it is adopted.

The sanitary supervision of the ice-cream industry requires special attention. Ice cream is frequently made from inferior grades of milk and cream under very unsanitary conditions, and is eaten largely by children and invalids who are especially susceptible to the communicable diseases. The factories should be inspected and rated by the score-card system, and the raw materials and finished product should be analyzed. The inspectors should pay particular attention to the care of utensils, the prevalence of flies, and carelessness and indifference in the use of the fingers in handling and tasting the ice cream. Publication by the health authorities of the results of the inspections and analyses brings excellent results.

The health authorities should enforce strict cleanliness in places where other milk products, such as skim milk, buttermilk, condensed milk, and butter are produced and handled. So far as practicable, either the raw materials or the finished products should be pasteurized.

All meat shipped in interstate or foreign commerce is inspected by Federal inspectors of the Bureau of Animal Industry of the Department of Agriculture, under the provisions of the United States Pure Food Law of 1906. The States should all establish systems of State inspection and licensing of slaughter-houses and slaughtering, as a great deal of meat is killed and consumed within State borders which, in the absence of State supervision, is not subject to any inspection. Where the State authorities are inadequate the municipal authorities should perform this duty.

The sanitary supervision of bakeries, confectioneries, restaurants, markets, and soda fountains is a function of local health departments. The sanitary requirements of these places have been discussed in earlier chapters.

Infant Welfare Work. This is one of the greatest problems of preventive and social medicine. Its importance was not appreciated until recently; heretofore most of the work having been undertaken by philanthropists. The question is now regarded as a subject for public health administration, the social agencies coöperating with the health authorities in reducing infant morbidity and mortality.

The conditions that must be overcome or improved in order to reduce infant mortality are briefly as follows: Ignorance and poverty; bad housing; overcrowding and filth; impure milk; flies; industrial employment of prospective and recent mothers; and the effects of bad midwifery and obstetrics. Many of these conditions can and are being improved by public health authorities, but most of them present sociological aspects that can be remedied only with the assistance of charitable and social agencies.

The most effective measures, aside from the promotion of municipal hygiene, that may be undertaken by local health authorities and welfare societies to reduce infant mortality are home instruction of mothers by infant hygiene nurses, and the establishment of infant welfare stations. The improvement in the milk supply is an important factor in the promotion of infant and child hygiene, but it is now recognized that its influence has been somewhat overestimated. The best grades of milk, such as certified milk, are beyond the means of those most needing it, and its distribution at reduced prices has had a tendency to discourage breast feeding. Institutional care of the children of the poor has proved a disappointment, as the mortality rates remain high. The best results are attained by keeping the children with their mothers and instructing and improving the conditions of the mothers.

Infant welfare nurses should be graduates of good hospital training schools, preferably with some special experience in baby work and some knowledge of the methods of social work. A number cf infant welfare organizations undertake both the pre-natal and post-natal instruction of mothers. In the pre-natal work information of pregnant women is secured as early as possible, and they are kept under observation and instruction by competent visiting nurses until the time of delivery.

In home post-natal instruction the nurse pays particular attention to the following subjects: Feeding; ventilation; clothing; discouragement of the use of drugs and remedies not prescribed by the physician and of false nipples and other mechanical devices used to quiet infants; protection of the child against possible modes of infection.

Breast feeding is strongly urged, but if artificial feeding is necessary, advice and instruction are given on the details of the latter and on the home modification of milk. The nurses must try to prevent the effects of hot, humid, and stagnant air in the homes of the poor by attempting to secure proper ventilation at all seasons. The results are frequently discouraging. Mothers must be instructed as to the dangers of tight clothing for infants, and impressed with the fact that in hot weather very little clothing is needed. The child must be protected against dust, dirt, and flies, and against possible infection of the eyes by the gonococcus; early vaccination must be urged. In cases of infantile diarrhea the excreta and soiled articles should be disinfected in order to protect other young children in the family. The nurse regulates the hours of sleeping of the child and teaches the mother the proper methods of bathing and otherwise caring for her infant. She should see that the child is taken once a week to the consultation at the infant welfare station to be examined and weighed.

Nurses should work under the health officer or under proper medical control; they should undertake no duties or assume no responsibilities which properly belong to physicians, such as prescribing medicines, special diets, etc. When the children under their care are sick they should give them such nursing care as is consistent with their duties toward their other charges. The nurses are in a favorable position to advise the family on all hygienic matters and to arrange for procuring milk and food from milk stations and diet kitchens. They should refer deserving cases to the proper charitable organizations, and urge medical attention when such is desirable. Welfare nurses should be appointed special inspectors of the board of health even when maintained by unofficial organizations.

Infant welfare stations are a later development of the milk station system maintained for the distribution of the better grades of milk. The improvement in the general milk supply, the teaching of home modification of milk, and the emphasis placed upon maternal nursing have caused the distribution of milk at the welfare stations to assume a place of secondary importance. The most important function is to keep the children under expert supervision and the mothers under medical instruction.

A medical director is usually appointed to have charge of the entire work of the welfare station. Two or more physicians coöperate with him and are assigned days at the babies' clinics. Usually a physician is asked to serve on consecutive clinic days, the season being divided up between the medical director's assistants. The work of the nurse is divided into examining the babies at the station, dispensing milk, and visiting the babies in their homes.

In some cities infant welfare stations are supported by public funds, in others by various charitable and social service organizations. They are, however, in no sense a charity, but are coming to be looked upon as educational centers as much so as the public school. Many mothers who are beyond financial want are referred to the stations by their family physicians in order that they may be taught the proper care of their babies.

The Public Health Nurse. The latest addition to the staff of public health authorities is the public health nurse. Through her the activities of the authorities have been extended into the broad field of personal hygiene. Her services were first utilized in the anti-tuberculosis campaign, later as the infant welfare nurse by charitable and social welfare agencies. The primary duty of the public health nurse is individual advice and instruction on prophylactic measures. Merely oral instruction is of little value to the class of people among whom the nurses work; it must be combined with encouragement and practical assistance. This takes the form of keeping the patients in touch with charitable organizations, making hospital arrangements, and the performance of a limited amount of incidental minor nursing. The public health nurse must be distinguished from the "district" or "visiting" nurses maintained by charitable societies and insurance companies, whose duties are curative rather than prophylactic in their nature.

Public health nurses, whether maintained by the authorities or by private organizations, should be appointed special health inspectors. In this capacity they should perform incidental inspection, noting such matters as defective housing conditions, the breaking of quarantine, etc., which should be reported to the sanitary inspectors. They should be trained nurses, preferably with a social service training, such as is now provided in connection with some hospitals, dispensaries, and social settlements.

PART II—THE COMMUNICABLE DISEASES

CHAPTER 1

DISEASES SPREAD BY ORAL AND NASAL DISCHARGES

Tuberculosis (Pulmonary)

Synonyms. Consumption, phthisis.

Definition. A chronic (at times acute) disease, characterized by specific lesions in the form of either separate nodular masses or diffuse growths which infiltrate the tissues of the lungs. Aggregations of tubercles give rise to tubercular masses. Tubercles undergo caseation and sclerosis, later ulceration, as the result of pyogenic infection, or less frequently, calcification.

Geographical Distribution. The known world, but more extensively in warm than cold climates. Local conditions have a stronger predisposing influence than geographic position. It is more frequent in densely populated sections than in rural districts. It is rare in mountainous countries, due to the purity of the atmosphere and the elevation.

Predisposing Conditions. The American Indian and the African are particularly susceptible. In America it is quite prevalent among the first and second generations of Irish immigrants. Hereditary influence can be traced in 10 to 40 per cent., more frequently through the mother. Children reared by tuberculous parents are in grave danger of being infected. A predisposition may be acquired as the result of defective food supply, childbirth, living and working in poorly ventilated rooms, etc. Children of drunkards, sufferers from cancer, syphilis, etc., inherit a low power of resistance, but the tendency may be overcome by proper hygienic environment during the early years of life.

Tuberculosis occurs as a sequel to many diseases—influenza, measles, pneumonia, whooping cough, typhoid fever, and diabetes mellitus.

Pulmonary tuberculosis is most common during the third decade of life.

Females are somewhat more liable than males, as pregnancy is a predisposing factor, and they are more exposed than males, living more of an indoor life.

Humidity of soil and atmosphere predisposes to the disease, as do climates having sudden variations of temperature or continued low temperatures with moisture.

Infectious Agent. *Bacillus tuberculosis* (human). (In rare instances the bovine tubercle bacillus has been proved to be the cause of a pulmonary tuberculosis.)

Source of Infection. The specific organism present in the discharges, or articles freshly soiled with the discharges from any open tuberculous lesions, the most important being sputum. Of less importance are discharges from the intestinal and genito-urinary tracts, or from lesions of the lymphatic glands, bone and skin.

Dissemination. Man himself is the principal agent in the dissemination of human pulmonary tuberculosis. Most cases are the result of contact infection, using the term in its broadest sense, implying the rather quick transference of fresh infective material from one person to another through a short distance in a brief space of time. It occurs by both direct and indirect contact; direct as by kissing or droplet infection, indirect by soiled fingers or objects such as pipes, toys, drinking utensils, etc., or through contaminated food. It is a family or house disease, and its dissemination is the result of close association between the sick and the well, and does not necessarily imply actual physical contact.

Flies probably carry a few infections from exposed sputum to food, lips, or fingers. There is the possibility of its dissemination by dust. The fact that tuberculosis apparently shows a diminution following purification of water supplies by filtration seems to show that a few cases are due to contaminated water.

Portal of Entry. There is some doubt whether the tubercle bacillus enters the body by inhalation or ingestion. The consensus of opinion is that the majority of infections of pulmonary tuberculosis are through the upper respiratory passages or through the tonsils, and that it is impossible to state even approximately the frequency of infection through the digestive tract.

There is no true hereditary transmission, though the bacilli occasionally pass congenitally from the mother to the fetus through the placenta. Tubercle bacilli are not found in the seminal fluid, spermatozoa, or ova. The presence of a tubercle bacillus in an ovum would kill the ovum. It is the tendency or predisposition to the disease that is transmitted.

Incubation Period. Variable and dependent upon the type of the disease.

Period of Communicability. Exists as long as the specific organism is eliminated by the host. Commences when a lesion becomes an open one, i.e., discharging tubercle bacilli, and continues until it heals or death occurs.

Immunity. Human beings must have a certain amount of immunity to tuberculosis and frequently recover spontaneously from the infection, otherwise the race would probably have ceased to exist many generations ago. The resistance increases with advancing years. This is probably explained by the fact that infections, especially among city dwellers, have occurred in most people of thirty years of age and upward. Man can, however, resist only a certain amount of infection. The factor of safety is small, as the natural immunity is not strong enough to overcome grave infections. The gravity of the infection is determined by the number of the bacilli, the virulence of the strain, and the frequency of reinfections.

Resistance to tuberculosis is increased by the careful observance of personal hygiene, good food, and fresh air, and decreased by dissipation, overwork, poor ventilation, malnutrition, etc.

There is no antitoxic immunity, and the tuberculins are not true antitoxins. Such immunity as exists is best explained by the anaphylactic reaction, which helps to protect the subject against invasion by the tubercle bacillus and guards it against spread of the infection after it is localized. There is little resistance to the primary invasion, but the second is followed by a violent reaction. The natural protecting agents, such as the germicidal substances of the blood, phagocytic cells, and antibodies, are concentrated at the point of invasion. Protection against extension of the infection is due to the same processes.

The anaphylactic reaction is probably stimulated by small amounts of tuberculin produced within the tubercular area. When this is not produced autogenously in sufficient amounts, as in chronic lesions of the bones or inactive lesions of the skin or lymphatic glands, the reaction may be stimulated by the injection of small amounts of tuberculin. The power of reaction is destroyed by too large amounts or too frequent dosage. If the mechanism of immunity is thus destroyed and the body offers no resistance, death follows as a result of the infection.

Mild infection with bovine tubercle bacilli causes a certain degree of immunity against the human variety. Children who have had glandular tuberculosis, generally contracted through milk, are less apt to have pulmonary tuberculosis in later life. The human variety of tubercle bacilli injected into cattle produce a definite immunity against the bovine strain. This is not without danger to consumers of food products derived from the cattle.

Apparent racial immunity is probably due to character and quantity of nutrition, exposure, modes of life, etc.

Prophylaxis. General Measures: 1. Education of the public in regard to the dangers of tuberculosis and the methods of control, with special stress upon the danger of exposure and infection in early childhood.

2. Provision of dispensaries and visiting nurse service for discovery of early cases and supervision of home cases.

3. Provision of hospitals for advanced cases, and sanatoria for the treatment of early cases.

4. Provision of open-air schools and preventoria for pre-tuberculous children.

5. Improvement of housing conditions and the nutrition of the poor.

6. Ventilation, and elimination of dusts in industrial establishments and places of public assembly.

7. Improvement of habits of personal hygiene and betterment of general living conditions.

8. Separation of babies from tuberculous mothers at birth.

The prevention of tuberculosis is being worked out by the medical profession, the sociologists, and the economists, and the results so far attained are most gratifying. An appreciable decrease in the disease in the lifetime of a generation is all that can be expected. Many years must pass before it is eradicated, but with the diminution in number of cases sterner measures, such as compulsory isolation, may be taken. The campaign of education by means of pamphlets, popular articles in the lay press and magazines, lectures, moving pictures, exhibits, and meetings is placing the facts concerning the disease plainly before the public.

The general uplift of mankind, the raising of the standard of living, and the increased well-being that has taken place in our time have been powerful factors in diminishing the spread of tuberculosis. Improving the housing conditions of the poor not only assists the lowly, but tends to prevent the spread of the infection to those more fortunately placed in life.

THE INFECTED INDIVIDUAL AND HIS ENVIRONMENT. 1 *Recognition of the Disease.* By clinical symptoms and by thorough physical examination, confirmed by bacteriological examination and serological tests.

2. Isolation of such "open" cases as do not observe the precautions necessary to prevent the spread of the disease.

3. *Immunization.* None.

4. *Quarantine.* None.

5. Concurrent disinfection of sputum and articles soiled with it. Particular attention should be paid to prompt disposal or disinfection of sputum itself, of handkerchiefs, cloths, or paper soiled therewith, and of eating utensils used by the patient.

6. *Terminal Disinfection.* Cleaning and renovation.

Personal prophylaxis is based upon avoidance of the infection and close attention to the rules of personal hygiene. Intimate association with persons whose sputum contains tubercle bacilli must be avoided, especially in small and ill-ventilated work-rooms or sleeping-rooms. Occupying the same bed with a tuberculous person is very dangerous. The longer and more intimate the contact the graver the danger, especially with careless or ignorant tuberculous subjects, whose sputum is a constant menace.

Mechanical obstructions to breathing, such as adenoids, should be removed. Imperfectly developed chests in the young should be corrected by outdoor play and regulated breathing exercises.

States and municipalities should require the compulsory notification of tuberculosis. The records should be confidential, so as to minimize the harm, such as possible loss of occupation, to the patient.

MILITARY. In time of peace tuberculosis causes more deaths and more discharges in the army than any other disease. Its prevention is based upon care in selecting and examining recruits and the maintenance of good hygiene of the soldier and his surroundings, especially an abundance of fresh air, thus preserving his natural immunity.

It is obviously impracticable by the ordinary methods of examination to detect all the incipient cases among men presenting themselves for enlistment or selected by the draft. Greater care is now being exercised in this matter than ever before. After arrival at the cantonments, training camps, etc., the men are most carefully examined by trained specialists now holding commissions in the Reserve Corps of the United States Army. Such bacteriological examinations and serological tests as are deemed necessary are made, and many incipient cases are being detected; nevertheless, it is inevitable that a certain number of infected recruits will be accepted.

The infection may exist in a latent or passive form, in the lymphatic glands, for instance, and only requires the conditions frequently met with in military life to flame up into active lesions. In all armies the majority of cases develop during the first six months of service, too soon to charge the infection to army conditions, unless such service has been particularly strenuous, involving hardships and exposure elsewhere than in training camps.

The barrack dormitories should not be overcrowded. When each man has less than 60 square feet of floor space and 720 cubic feet of air space and gets less than from 2000 to 3000 cubic feet of fresh air without draft every hour, the tuberculosis rate of admission to the sick report is almost sure to rise.

Early recognition of cases is most important. The noncommissioned officers should be instructed to send immediately to the medical officer for examination, any man, especially a recruit, who has a suspicious or habitual morning cough.

Strict rules, with inevitable punishment for offenders, must be enforced against promiscuous expectoration. The understanding of the men must be appealed to, and all the enlisted men should receive such instruction in practical hygiene from the company and medical officers as will stimulate and maintain their interest in the general good health of their company and garrison.

Tuberculosis cases are either discharged on certificate of disability, or, if they prefer it and their condition permits, they are sent to the U. S. Army sanatorium at Fort Bayard, New Mexico, where after discharge from the service they may be kept under treatment as beneficiaries of the Soldiers' Home.

Very few men, when the disease is arrested, are returned to duty, as active military life is almost certain to cause a recurrence.

Naval. Prophylaxis against tuberculosis in the navy is founded upon the same basic principles as military prophylaxis, with the addition of certain procedures made necessary by life aboard ship. The same care should be taken by the naval examining surgeons to prevent the enlistment of men and boys who may have the disease in an incipient form or who may be predisposed to tuberculosis. There has been a tendency in the past to accept men of a lower physical standard for such ratings as cook, steward, or musician. This should be discontinued.

The precautions to be taken at naval training stations and naval and marine barracks differ in no essential respects from those necessary at military barracks.

The early detection of tuberculosis aboard ship is of even more importance than on shore, as ship life offers ideal conditions for its transmission. Every facility should be available, especially on hospital ships, for diagnosis by the most refined clinical methods. Frank and suspicious cases alike should be transferred at the first opportunity to a hospital ship or naval hospital.

In prophylactic measures aboard ship, especially against those diseases spread by discharges from the mouth and nose, "Every effort should be made in the routine care of the ship to prevent the fluids from the mouth of one man from gaining access to the body of another." (Gatewood.) Mess gear and dish cloths should be scalded after each meal. Spit-kids containing water should be placed conveniently about the decks, and spitting on the deck promptly punished.

The steam hose should be used in the crew's water-closet to disinfect the floor, wood-work, and spit-kids. The damp cloths and swabs used for cleaning between decks should be daily disinfected by steam.

The linoleum covering the decks should be kept in good condition, in contact with the deck and well shellacked.

All ships should be provided with sanitary drinking fountains. Where the common drinking-cup is used it should be immersed immediately after use in a weak solution of formaldehyde. It should be kept free from nicks and rough edges.

The air between decks contains much dust derived from the mouths, nares, clothing, and food of the crew, therefore men such as yeomen, hospital corps men, storekeepers, etc., whose duties are largely below, should be required to spend part of their time on deck.

The ship should be kept as dry as possible without dust. The use of brooms between decks should be reduced to a minimum. Some adaptation of the vacuum cleaner may eventually solve this problem.

The occasional disinfection of the decks with bichloride of mercury solution and the fumigation of the sick bay with formaldehyde are desirable in the presence of diseases spread by oral and nasal discharges.

No officer or man in the sea-going personnel of the navy should ever be returned to duty if the diagnosis of pulmonary tuberculosis has been definitively made. "No enlisted patient having had or having the disease should be discharged in any other way than by medical survey, in order that the character of the discharge may forever be a bar to reënlistment." (Gatewood.) Even cases of recovery or apparent recovery should not be allowed to reënlist, as they have not the resistance suitable for a naval life. While they may possibly not be foci of infection, they readily become reinfected themselves.

Diphtheria

Synonyms. Diphtheria, angina maligna, croup.

Definition. An acute communicable disease characterized by the formation of a membraneous, fibrinous, whitish or grayish deposit at the seat of infection, generally the throat, and often the nasal passages and larynx. It is clinically characterized by irregular fever, prostration, albuminuria, a secondary toxemia, and often cardiac failure. It is frequently followed by peculiar paralyses.

Geographical Distribution. Until recent years diphtheria was considered a disease of sparsely settled localities. Lately the diphtheria mortality of towns has become relatively greater than that of rural districts. It is endemic in large centers of population. Epidemics and pandemics occur cyclically, possibly due to combinations of such factors as the development of a virulent strain of the bacillus, the opening of schools, and the growth of susceptible children.

It is more of a continental than an insular disease, and is met with less frequently in the tropics than in cold and temperate climates.

Predisposing Conditions. Diphtheria is in the main a disease of childhood, most cases occurring between the second and tenth years, after which susceptibility diminishes rapidly. Sex has no influence. The growth of the bacillus is favored by humidity. Damp houses and cellars favor the spread of the disease by predisposing the occupants to colds and sore throats. Unfavorable sanitary surroundings, which tend to lower vitality, increase the susceptibility to diphtheria.

Infectious Agent. *Bacillus diphtheria.*

Source of Infection. Discharges from diphtheritic lesions of the nose, throat, conjunctiva, vagina, and wound surfaces. Secretions from the nose and throat of carriers of the bacillus.

Dissemination. Direct contact infection, as by kissing, or exposure to droplet infection in coughing, sneezing, and speaking, is the most frequent mode of transmission, but many infections are conveyed by indirect contact. This is common among children by means of contaminated toys, fingers, slate pencils, food, and other articles that readily pass from the mouth of one child to that of another. Probably most cases of so-called air-borne infection are instances of droplet infection, as the bacillus soon dies when exposed to the air and sunlight.

Bacillus carriers are an important factor in the dissemination of diphtheria. Many persons who come in contact with the disease harbor the bacilli, but retain their health, and many who have had no known association with infected persons carry the organism in the nose and throat. In the latter case the bacilli have usually little or no virulence, though it may be possible to raise it by passage through susceptible individuals. Diphtheria is probably kept alive in a community by virulent organisms in immune subjects and not by non-virulent strains. It would be impracticable to attempt to isolate the latter class of carriers. The carriers most to be feared distribute a virulent strain from a patient, convalescent, or contact.

Milk is a good culture medium for the diphtheria bacillus. It is usually contaminated by cases or carriers on the farm, in the dairy, or in the store. The bacillus has been isolated from milk from cows with mastitis, probably infected secondarily. Milk-borne diphtheria epidemics are not so severe as those of scarlet or typhoid fever.

Portal of Entry. In human beings the seat of election is usually the faucial mucosa; less frequently the nasal and laryngeal mucous membranes, and more rarely the conjunctiva and vulva are attacked. Cutaneous diphtheria and wound-infection diphtheria are sometimes seen. The bacilli do not penetrate the surface, but remain at or very near the site of infection. They do not enter the lymphatic or circulatory systems.

Incubation Period. Usually two to five days, occasionally longer if a healthy carrier stage precedes the development of clinical symptoms. In virulent epidemics and experimental cases the incubation stage is from twelve hours to two or three days.

Period of Communicability. Until virulent bacilli have disappeared from the secretions and the lesions. The persistence of the bacilli after the lesions have healed is variable. In fully three-quarters of the cases they disappear within two weeks. In 95 per cent of cases the bacilli disappear in four weeks. In exceptional cases virulent bacilli remain in the throat and discharges for from four to six months.

Immunity. By means of Schick's intracutaneous test it has been ascertained that the blood of many normal persons contains diphtheria antitoxin in demonstrable quantities. Not being susceptible to diphtheritic infection, it is not necessary to give them prophylactic injections of antitoxin after exposure.

The test is as follows: One-fiftieth of the minimum lethal dose of diphtheria toxin for a guinea pig, diluted to make 0.1 c.c. of fluid, is injected intracutaneously. A local reaction follows if there is less than 1/30 of a unit of antitoxin per cubic centimeter of blood. This amount is considered sufficient to protect against diphtheria. If at the end of twenty-four hours the site of the injection shows a definite inflammatory reaction, the subject is susceptible. Those showing no reaction are insusceptible.

Immunity in diphtheria is largely antitoxic. That following a natural attack may last for months or years, though it may be of short duration. Second and third attacks are not infrequent. The existence of healthy carriers shows that some other factors or predisposing conditions besides the presence of the bacillus are necessary to cause the disease.

Infants may inherit some resistance from their mothers and absorb some through the mother's milk. Young babies, especially if breast fed, are seldom exposed to the infection.

Prophylaxis. General Measures: 1. Pasteurization of milk supply.

2. Application of Schick's test to all contacts, and immunization of all susceptibles.

3. Application of Schick's test to all children.

4. Immunization by toxin-antitoxin inoculation of all susceptibles.

5. Determination of presence or absence of carriers among contacts, and, as far as practicable, in the community at large.

The infected individual and his environment:

1. *Recognition of the Disease.* By clinical symptoms with confirmation by bacteriological examination of discharges.

2. *Isolation.* Until two cultures from the throat and two from the nose taken not less than twenty-four hours apart, fail to show the presence of diphtheria bacilli. Isolation may be terminated if persistent diphtheria bacilli prove avirulent. When termination by culture is impracticable, cases may be terminated with a fair degree of safety, as a rule, sixteen days after onset of the disease.

3. *Immunization.* Exposed susceptibles to be promptly immunized by antitoxin. (By susceptibles is meant such individuals as are found to be non-immune by the Schick test, i.e., those who give a positive reaction.)

4. *Quarantine.* All exposed persons until shown by bacteriological tests not to be carriers.

5. Concurrent disinfection of all articles which have been in contact with the patient and all articles soiled by discharges from the patient.

6. *Terminal Disinfection.* At the end of the illness, thorough airing and sunning of the sick room, with cleaning or renovation.

The control of diphtheria among the general population is difficult, as the application of the most efficient prophylactic measure, the isolation of all carriers, is impossible. This may become possible when a reliable and convenient method is found to distinguish, morphologically, between virulent diphtheria bacilli and pseudo-diphtheria bacilli.

Diphtheria is in most communities, and should be in all, a notifiable disease. Houses must be placarded and the cases isolated. Hospital treatment in special hospitals is desirable though the case may be cared for in the household if the patient and nurse can be quarantined from the rest of the family and intelligent nursing and bedside disinfection practiced. Nevertheless there is always the danger that some member of the household will become a carrier of a virulent strain of bacilli.

Early and prompt laboratory diagnosis is a most commendable procedure now made possible by many boards of health and should be by all.

In epidemics in institutions the isolation of all cases and carriers is of prime importance and is the best preventive measure. Even those who show cultures which only morphologically resemble the diphtheria bacillus should be isolated.

On the appearance of diphtheria in an institution the entire personnel, executive force and inmates, should receive a prophylactic dose of 1000 units of diphtheria antitoxin. This must be repeated every ten days or two weeks as long as cases appear. These inoculations will not of themselves check the epidemic, as the bacilli remain in the throats of those immunized and infect them after the immunity has passed away.

Nurses and physicians must guard most carefully against droplet infection when in close contact with patients. The practice of personal cleanliness, especially concerning putting things in the mouth and washing the hands before meals, conduces to one's safety. It is well for every person to have his own glass, cups, spoons, towels, etc., when in the presence of or in danger of cases or an epidemic.

Military. In prophylaxis against diphtheria dry, sunny, well-ventilated barracks free from overcrowding are important. Anything that predisposes to pharyngitis and tonsilitis, such as dampness arising from the use of too much water in cleansing the floors, must be avoided. The avoidance of the use of articles in common and the care of eating utensils, as heretofore described, must be insisted upon.

All suspicious cases must be immediately isolated or sent to a military hospital and a prompt laboratory diagnosis secured.

When a case occurs in an organization the following steps should be taken:

1. Promptly remove and disinfect the clothing, bedding, and other articles that have been exposed. The squad room or dormitory in which the case developed should be disinfected.

2. Take a nose and throat culture on blood serum from each man in the organization. This is to detect developing cases and carriers.

3. Perform the Schick test on all men of the organization.

4. When the report from the laboratory is received, isolate all men whose cultures show bacilli that are morphologically diphtheria.

5. Give a prophylactic dose of antitoxin (1000) units to

those who have been in contact with a recognized case of the disease, and who have a positive Schick reaction.

Naval. During the period of rapid expansion of the navy, 1901-1905, the admission ratio for diphtheria and the other epidemic diseases spread by oral and nasal discharges was high. This was due to the enlistment of thousands of minors and young adults, far in excess of the accommodations provided for at the naval training stations. The barracks were overcrowded, poorly ventilated, often damp and insufficiently heated, lacked steam laundries, and had insufficient provision for the segregation of newcomers, and for the disinfection of clothing and persons. Recruits received from these stations carried the infections to the ships, especially the training ships. This was corrected, with a marked decrease in the admission ratio for all the epidemic diseases, by improved sanitation and prevention of crowding at the training stations and segregation of the recruits in groups for a period of twenty-one days on their arrival at the stations. This allows time for any of the acute epidemic diseases that may be present in the incubation stage to manifest itself before the men and boys mingle with the general body of recruits under training at the station.

The hygienic measures necessary at naval barracks differ in no essential particulars from those of military barracks, and the procedures to be taken on the occurrence of diphtheria are the same.

Aboard ship the prophylactic measures embrace those described under tuberculosis as necessary to prevent the diseases spread by discharges from the mouth and nose. Precautions against droplet infection are very important. In the face of as serious a disease as diphtheria the methods of control must be carefully carried out. Cases in which there is the slightest suspicion of diphtheria must be isolated, an early laboratory diagnosis obtained, and the necessary disinfection performed. The diagnosis is readily made with the microscopic outfits supplied to most men-of-war and to all hospital ships. The cases must be transferred to a hospital ship or naval hospital at the earliest possible moment. A careful bacteriological search should be made for carriers among the crew and officers, and when found these individuals should be transferred to a hospital or hospital ship.

The Bureau of Medicine and Surgery directs:

Cases and carriers should be isolated until three negative cultures from the throat and nose, taken not less than twenty-four hours apart, are obtained.

If after thirty days the organism still persists, a virulence test should be made. If the organism is found to be avirulent, the carrier may be discharged to duty with impunity. In searching for carriers it is important to culture material taken from both the throat and nose. If for any reason laboratory aid cannot be invoked, it would be quite proper to isolate as possible carriers all those showing evidence of enlarged or chronically inflamed tonsils.

Measles.

Synonym. Morbilli.

Definition. An acute and extremely contagious disease characterized by an initial coryza, fever in the earlier stages, catarrhal inflammation in the upper respiratory tract, and a peculiar papular eruption on the face and body.

Geographical Distribution. The occurrence of measles is independent of climatic influences. Its distribution has been found to be practically universal. It is constantly present in all large centers of population in the temperate zones, but is less prevalent in warm countries. In cities it tends to become epidemic at intervals of from two to four years, the outbreaks varying in extent and fatality. The disease disappears more completely between outbreaks than some of the other exanthemata. In small communities the intervals between outbreaks are longer and less regular.

Predisposing Conditions. The bringing together of human beings, children or adults, who have not had measles, is the strongest predisposing factor. Epidemics often break out in schools immediately after vacations. It is common in newly raised military organizations, especially among soldiers recruited from rural districts who have never before been exposed to the disease.

It appears to be a children's disease, because nearly everybody is attacked in childhood, and thus acquires a rather definite degree of protection.

It is more frequent in the colder months because of the closer association of human beings due to indoor life during that season.

Infectious Agent. A filterable virus.

Source of Infection. Buccal and nasal secretions of an infected individual. These are doubtless the sources of infection in most cases, though the secretion from the conjunctiva also contains the virus.

Dissemination. The usual mode of infection is by more or less direct contact during the early stages of the disease by means of discharges from the nose and mouth. It is rarely if ever transmitted by contacts or fomites, as the virus has no saprophytic existence and soon dies outside the body. Droplet infection occurs, but there is no general aerial dissemination of the virus.

It seems certain, from both experimental and epidemiological evidence, that the virus is *not* contained in the desquamating epithelium of measles cases.

Portal of Entry. This is in doubt, but it is presumed that the virus enters by the nose and mouth.

Incubation Period. Seven to eighteen days; usually fourteen days.

Period of Communicability. During the period of catarrhal symptoms and until the cessation of abnormal mucous membrane secretions—minimum period of seven days; from two days before to five days after the appearance of the rash.

Immunity. All ages are susceptible. An attack confers a fair degree of immunity. Second attacks are more common than in the other exanthemata; a few persons have the disease three or four times. Very young infants appear to have a relatively high degree of immunity, though they are occasionally infected.

A fatal ending of the disease is generally due to pneumonic complications. Measles apparently lowers the resistance to tuberculosis.

Prophylaxis. General Measures: 1. Daily examination of exposed children and of other possibly exposed persons. This examination should include record of the body temperature. A non-immune exposed individual exhibiting a rise of temperature of 0.5° C. or more should be promptly isolated pending diagnosis.

2. Schools should not be closed or classes discontinued when daily observation of the children by a physician or nurse is provided for.

3. Education as to special danger of exposing young children to those exhibiting acute catarrhal symptoms of any kind.

The Infected Individual and His Environment. 1. Recognition of the disease—Clinical symptoms. Special attention to rise of temperature, Koplik's spots and catarrhal symptoms in exposed individuals.

2. *Isolation.* During period of communicability.

3. *Immunization.* None.

4. *Quarantine.* Exclusion of exposed susceptible school children and teachers from school until fourteen days from last exposure. This applies to exposure in the household. Exclusion of exposed susceptible children from all public gatherings for the same period.

5. *Concurrent Disinfection.* All articles soiled with secretions from the nose and throat.

6. *Terminal Disinfection.* Thorough cleaning.

Modern preventive medicine has given us no effective prophylactic measures against measles. Isolation is almost useless as the damage has been done before the diagnosis can be made. However, isolation is worth while, as it prevents further spread of the disease by the isolated case. Early diagnosis is of the greatest importance. This applies particularly to orphan asylums, schools, barracks, camps, and ships. Koplik's spots should always be looked for when suspects are examined.

The reprehensible attitude of the lay public in considering measles a necessary evil is to be unqualifiedly condemned. Practically every human being in the endemic areas will sooner or later have measles, but the later in life they have it the less the danger of fatal pneumonic complications, especially if they receive careful nursing and protection. Parents should take pains to protect their children from infection by avoiding the known foci and observing the sanitary rules necessary to avoid the diseases spread by oral and nasal discharges.

Measles is seldom spread by carriers, and mild, atypical, and unrecognized cases are less numerous than in diphtheria, typhoid fever, and scarlet fever, but they do help to keep it alive during epidemics.

Measles is exceedingly contagious, therefore it is important to guard against droplet infection and indirect contact infection. Physicians should wear a gown while attending measles cases, and carefully wash their hands, face, and hair after leaving the sick-room. They should also wait a reasonable time, preferably with exposure to fresh air and sunshine, before attending other children.

Little good is accomplished by closing the schools to prevent the spread of measles, as it is spread mainly in the pre-eruptive stage. The children should be carefully examined every morning *before* they enter the school for signs of coryza, conjunctival injection, running at the nose, sore throat, cough, fever, and Koplik's spots. Children presenting any of these symptoms should be sent home and placed under observation.

Cases should be reported to the health department immediately, all visiting stopped, and the house placarded. When treated in the house it is difficult to prevent the spread of measles to the other susceptible members of the household. It is well to send away the children who have not had it. Constructive isolation, intelligent nursing, medical asepsis, and bedside disinfection of all articles exposed will control the disease, once the case is recognized.

Military. Measles is very common among young soldiers, is often a rather serious illness, and has caused more trouble to military sanitarians than all the other exanthemata, because it is so difficult to control and nearly always assumes epidemic proportions.

Methods of Control. 1. Take all possible steps to avoid overcrowding. Not only measles, but all respiratory diseases are much more apt to spread when the men are overcrowded.

2. Prompt notification of all cases or suspects.

3. Isolate all known cases in the hospital.

4. Determine as far as possible all contacts. All tent mates are contacts.

5. Find out what contacts have had measles. If a previous attack can be definitely ascertained, such men need not be isolated, as measles confers a fair degree of immunity. In case of doubt or when a history of German measles is given, isolate.

6. Place all non-immune contacts in a detention ward. If necessary, they are to be permitted to perform their duties for seven days after the contact (the minimum incubation period), but thereafter they must be strictly isolated and observed for ten days. If measles does not develop within eighteen days from last contact, they may be released.

7. Isolate in another ward or tent all soldiers of the organ-

ization who develop symptoms of coryza, as soon as the symptoms appear. Non-commissioned officers should be instructed to watch for and recognize symptoms of a cold, so that these cases may be isolated at the earliest possible moment. They should be treated with nasal and buccal sprays.

8. During epidemics every man who has not had measles should report daily for medical examination.

Naval. At navy yards, naval training stations, and marine barracks the methods of control of measles are exactly similar to those effective in the army. The essential points are the prevention of overcrowding, thus minimizing the danger of droplet infection, and a careful daily inspection of personnel, especially contacts, with a view toward detecting the disease in its earliest stage.

Aboard ship the same principles must guide the naval sanitarian. Epidemics such as formerly occurred on the training ships are no longer seen. When cases do occur they and all suspects must be promptly isolated, careful bedside disinfection practiced and the entire crew inspected daily to detect cases in the early stages. Cases should be transferred to a hospital or hospital ship as soon as possible.

Whooping Cough

Synonyms. Pertussis, tussis convulsiva.

Definition. Whooping cough is a highly contagious, specific affection, characterized by a catarrhal inflammation of the respiratory passages, associated with a peculiar spasmodic cough, ending in a whooping inspiration.

Geographical Distribution. The disease has practically a world-wide distribution, but is more severe and there are more endemic centers in the temperate zones than in the tropics. While it has visited most parts of the world it was introduced into some countries, such as Australia and New Zealand, as late as the nineteenth century. In some localities, as in Iceland and the Faroe Islands, it has occurred only when introduced from without.

It is more frequent and severe in cold weather. Most cases occur before the tenth year, after this its frequency rapidly diminishes, due to the fact that so many have suffered from it and partly to a lessened susceptibility. Some authorities state that girls are more liable to infection than boys. Station in life has no influence. Children with a catarrhal condition of the respiratory and digestive tracts are predisposed. It frequently follows measles, as the latter leaves the respiratory mucosa in a sensitive condition, favorable to the lodgment of the causative organism.

Infectious Agent. *Bacillus pertussis.*

Source of Infection. Discharges from the laryngeal and bronchial mucous membranes of infected persons (sometimes also of infected dogs and cats, which are known to be susceptible).

Dissemination. Whooping cough is most frequently transmitted by direct contact from person to person by means of fresh secretions from the respiratory tract, nose, and mouth. It is not air-borne in the general acceptation of that term, but is spread by droplet infection. Infection by indirect contact or by third persons is less frequent, but objects such as toys, cups, handkerchiefs, roller towels, etc., act as intermediary agents.

Portal of Entry. The bacilli evidently enter the body through the respiratory tract.

Incubation Period. From four to fourteen days, according to the condition of the patient's respiratory mucosa at the time of infection. If a catarrhal condition exists the period is shorter.

Period of Communicability. Particularly communicable in the early catarrhal stages before the characteristic whoop makes the clinical diagnosis possible. Communicability probably persists not longer than two weeks after the development of the characteristic whoop or approximately four weeks after the onset of catarrhal symptoms.

Immunity. There is no natural immunity. An attack confers a very definite immunity, generally for life. Second attacks are rare.

Prophylaxis. GENERAL MEASURES: Education in habits of personal cleanliness and in the dangers of association or contact with those showing catarrhal symptoms with cough.

THE INFECTED INDIVIDUAL AND HIS ENVIRONMENT. 1. *Recognition of the Disease.* Clinical symptoms, supported by a differential leucocyte count, and confirmed where possible by bacteriological examination of bronchial secretions.

2. *Isolation.* Separation of the patient from susceptible children, and exclusion of the patient from school and public places for the period of presumed infectivity.

3. *Immunization.* Use of prophylactic vaccination recommended by some observers. Not effective in all cases.

4. *Quarantine.* Limited to the exclusion of non-immune children from school and public gatherings for fourteen days after their last exposure to a recognized case.

5. *Concurrent Disinfection.* Discharges from the nose and throat of the patient and articles soiled with such discharges.

6. *Terminal Disinfection.* Cleaning of the premises used by the patient.

This disease presents the same difficulties in prophylaxis as measles. A diagnosis is difficult in the early stage, when it is most contagious, and the patient *may* transmit whooping cough six weeks after apparent convalescence.

Whooping cough should be promptly reported and the case constructively isolated. Strict confinement in a room is unnecessary; in fact, patients do better out of doors. While permitted out of doors they must not come in contact with other persons, especially children. While taking the air children should be accompanied by a caretaker to prevent their association with other children, and they should wear a brassard on the arm or a yellow flag on their clothing to warn nurses and parents of their contagious condition. The constructive quarantine should last until the spasmodic stage is over.

The public must be brought to realize the dangerous nature of whooping cough, and that it is dangerous before and after the "whoop." Great care should be taken to avoid the infection, and especially should children under five years be protected. Dogs and cats should not be allowed to come in contact with whooping-cough patients.

Mumps

Synonyms. Epidemic parotitis, parotiditis.

Definition. An acute, contagious disease characterized by a primary inflammation and swelling of the parotid glands, and occasionally by a metastatic involvement of the salivary glands, testicles, and in the female the mammæ.

Geographical Distribution. The distribution of mumps is practically coextensive with the habitable world. No particular climate will prevent its occurrence. Epidemics are recorded in Iceland, Lapland, throughout the temperate zones, India, Arabia, and the West Coast of Africa.

Predisposing Conditions. It is seen most frequently in childhood and adolescence. Adults and very young infants usually escape infection. Males are somewhat more prone to the disease than females. It is more frequent in spring and autumn, particularly during wet weather. Most large centers of population are endemic foci of mumps. As it is very contagious, it is apt to spread through institutions, schools, etc.

Infectious Agent. Unknown.

Source of Infection. Secretions of the mouth and possibly of the nose.

Dissemination. By direct contact with an infected person or with articles freshly soiled with the discharges from the nose or throat of such infected person. It spreads slowly and lasts a long time. At times it becomes curiously localized in a certain part of a city, or even of a school or institution.

Incubation Period. From four to twenty-five days. A period of eighteen days accepted as usual. A period of twenty-one days is not uncommon.

Portal of Entry. The virus presumably enters the body through the mouth.

Period of Communicability. Unknown, but assumed to persist at least until the parotid gland has returned to its normal size. Rosenau states that mumps is contagious before the symptoms appear, and for some time, even six weeks, after symptoms have disappeared.

Immunity. One attack usually is followed by permanent immunity, though well-established instances are on record of two or even more attacks.

Prophylaxis. General Measures. The sanitary precautions necessary in the prevention of mumps are those indicated for all diseases of this type. The avoidance of contact infection and especially droplet infection is the keynote of prophylaxis in this disease.

The Infected Individual and His Environment. 1. Recognition of the disease—Inflammation of Steno's duct may be of assistance in recognizing the early stage of the disease. The diagnosis is usually made on swelling of the parotid gland.

2. *Isolation.* Separation of the patient from non-immune children and exclusion of the patient from school and public places for the period of presumed infectivity.

3. *Immunization.* None.

4. *Quarantine.* Limited to exclusion of non-immune children from school and public gatherings for twenty-one days after last exposure to a recognized case.

5. *Concurrent Disinfection.* All articles soiled with discharges from the nose and throat of the patient.

6. *Terminal Disinfection.* None.

Military. The prevention of overcrowding and the education of the soldiers as to the danger of the trade in saliva are the salient features of the prophylaxis of mumps in the army.

When a case of mumps develops and the disease is epidemic among the surrounding population and the men are mingling freely with this population, little can be expected from isolation, as fresh infections will continue to be received from the outside. If the camp or garrison is located at some distance from other foci of infection, prompt isolation may prevent an epidemic.

Methods of Control. 1. Isolate the case in the hospital or a tent for six weeks.

2. Place all non-immune contacts in a detention ward for three weeks. An attack of mumps may be considered as having conferred immunity.

3. Should no further cases develop all contacts may be discharged at the end of three weeks. Should secondary cases occur, these in turn must be isolated for six weeks, and the period of detention for the remaining contacts should be three weeks from the last case of mumps.

These methods of control are quite effective if action is taken when the first case occurs. The virus is rather feebly contagious and all infected cases may be removed at once from the general command. If action is delayed until a number of cases develop, or if fresh cases continue to be introduced from the outside, little can be expected from isolation, and the period of incubation and infectiousness combined is so long (nine weeks), that isolation is sure to become unduly burdensome, as well as ineffective. (Vedder.)

Naval. In the naval forces ashore mumps must be combated by the same methods prescribed for the army.

Aboard ship, early diagnosis with isolation, bedside disinfection, and removal of cases to a hospital or hospital ship are effective in averting an epidemic, providing fresh infection is not brought aboard.

Scarlet Fever

Synonyms. Scarlatina, scarlet rash.

Definition. An acute, contagious, self-limiting disease characterized by sudden onset, fever, diffuse exanthem, and angina.

Geographical Distribution. Scarlet fever is a widespread disease, though less so than measles and smallpox. It is endemic in all the large cities of the world, though it has never firmly established itself in Asiatic, Australian, or African cities except in Algiers. Smaller towns and rural districts are visited, and the epidemics are usually traceable to imported infections. The disease is rare in the tropics.

Predisposing Conditions. Age is the most important predisposing factor; 90 per cent of fatal cases are under the tenth year, and 85 per cent of all cases are under the age of puberty. It is rare in the first year of life.

Scarlet fever is most prevalent during the colder months, when children are congregated in schools and playgrounds.

Infectious Agent. Unknown.

Source of Infection. The belief at present is that the virus is contained in the secretions from the nose and throat, in the blood and in the lymph nodes, and that it is given off in the discharges from the mouth, the nose, the ears, and from broken-down glands of infected persons.

Dissemination. The disease is most often acquired by direct contact with a patient or convalescent. Light cases are as contagious as severe forms. Mild cases, without eruption, readily disseminate it, especially in schools. Third persons may transmit it on their clothing, and contacts may act as carriers. Indirect contact infection by means of articles such as drinking-cups, toys, etc., contaminated by the secretions of the mouth is not uncommon. Droplet infection is frequent.

Outbreaks due to milk contaminated from human sources are rather frequent. In a few epidemics infection was supposed to be due to disease of the cow.

Portal of Entry. The virus probably enters through the mouth and respiratory passages. Monkeys have been experimentally inoculated through the pharynx with throat swabs from scarlet fever patients.

As the virus circulates in the blood there is a possibility of fetal infection.

In surgical scarlet fever the infection is apparently through open wounds. Some assert that this form is of septic origin, or that the scarlatina is merely accidental.

Incubation Period. Two to seven days, usually three or four days.

Period of Communicability. Four weeks from the onset of the disease, without regard to desquamation, and until all abnormal discharges have stopped and all open sores have healed.

Immunity. One attack usually confers immunity, but second and even third attacks are known. Many persons resist infection temporarily or permanently. Breast-fed infants seldom take the disease, because of the diminished chances of the virus entering their mouths. The immunity of adults is due partly to mild, unrecognized attacks in childhood.

Prophylaxis. General Measures: 1. Daily examination of exposed children and of other possibly exposed persons for a week after last exposure.

2. Schools should not be closed where daily observation of the children by a physician or a nurse can be provided for.

3. Education as to special danger of exposing young children to those exhibiting catarrhal symptoms of any kind.

4. Pasteurization of the milk supply.

The Infected Individual and His Environment. 1. *Recognition of the Disease.* By clinical symptoms.

2. *Isolation.* In home or hospital, maintained in each case until end of the period of infectivity.

3. *Immunization.* None.

4. *Quarantine.* Exclusion of exposed susceptible children and teachers from school, and food handlers from their work, until seven days have elapsed since last exposure to a recognized case.

5. *Concurrent Disinfection.* Of all articles that have been in contact with a patient and all articles soiled with discharges of the patient.

6. *Terminal Disinfection.* Thorough cleaning.

Preventive measures in scarlet fever are hampered by our lack of precise knowledge of its cause and modes of dissemination. The important factors are early diagnosis, bedside disinfection, and isolation. Early diagnosis is especially important in schools, and is accomplished by means of medical inspection. It is of little value to close city schools in time of scarlet fever epidemics, as the children are associated in the streets and tenement houses. This measure is effective in the country where the children are separated.

Cases may be treated at home if a suitable room and intelligent nursing are available. Susceptible persons should be sent away from the house. Careful bedside disinfection of all secretions and discharges liable to contain the virus must be practiced. The observance of medical asepsis is very essential.

Military. Methods of Control. 1. Prevention of overcrowding and contact infection.

2. Pasteurization of all milk supplies.

3. Prompt notification.

4. Isolation of cases in hospital or tents and bedside disinfection for the period of infectivity.

5. Isolation of all contacts in small groups during the maximum incubation period.

Naval. The same principles that guide the military sanitarian must be followed by his naval *confrère* in preventing and controlling scarlet fever. Early removal of cases from ships is highly essential in preventing the spread of the disease, once it makes its appearance.

German Measles

Synonyms. Rubella, rotheln.

Definition. An acute contagious disease having no prodromal stage. It is characterized by slight fever, enlargement of the post-cervical glands, and an efflorescence on the skin.

Geographical Distribution. Epidemics have been reported from practically every part of the world.

Predisposing Conditions. As compared with measles, the incidence shows a higher percentage of adults. Crowded and unhygienic habitations are the strongest predisposing factors.

Infectious Agent. Unknown.

Source of Infection. Secretions of the mouth and possibly of the nose.

Dissemination. By direct contact with the patient or with articles freshly soiled with the discharges from the nose or throat; very contagious in crowded institutions.

Portal of Entry. It is assumed that the virus enters by the nose and throat.

Incubation Period. From ten to twenty-one days.

Period of Communicability. Eight days from onset of the disease.

Prophylaxis. The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms.

2. *Isolation.* Separation of the patient from non-immune children, and exclusion from school and public places for the period of presumed infectivity.

3. *Immunization.* None.

4. *Quarantine.* None except exclusion of non-immune children from school and public gatherings, from the eleventh to the twenty-second day from date of exposure to a recognized case.

5. *Concurrent Disinfection.* Discharges from the nose and throat of the patient and articles soiled by discharges.

6. *Terminal Disinfection.* Airing and cleaning.

The reason for attempting to control this disease is that it may be confused with scarlet fever during its early stages; each person having symptoms of the disease should therefore be placed under the care of a physician and the case should be reported to the local department of health.

Septic Sore Throat

Definition. An acute inflammation of the tonsils and pharynx due to the streptococcus (hemolytic type).

Geographical Distribution. A number of epidemics have been reported from American and British cities.

Source of Infection. The human naso-pharynx, usually the tonsils, any case of acute streptococcus inflammation of these structures being a potential source of infection, including the period of convalescence of such cases. The udder of a cow infected by the milker is an occasional source of infection. In such udders the physical signs of mastitis are usually absent.

Dissemination. Direct or indirect human contact; consumption of raw milk from an infected udder.

Portal of Entry. The mouth.

Incubation Period. One to three days.

Period of Communicability. In man, presumably during the continuance of clinical symptoms; in the cow, during the continuance of discharge of the streptococci in the milk, the condition in the udder tending to spontaneous subsidence. The carrier stage may follow convalescence and persist for some time.

Prophylaxis. GENERAL MEASURES. 1. Exclusion of suspected milk supply from public sale or use, until pasteurized. The exclusion of the milk of an infected cow or cows in small herds is possible when based on bacteriological examination of the milk of each cow, and preferably the milk from each quarter of the udder at frequent intervals.

2. Pasteurization of all milk.

3. Education in the principles of personal hygiene and avoidance of the use of common towel, drinking, and eating utensils.

THE INFECTED INDIVIDUAL AND HIS ENVIRONMENT. 1. *Recognition of the Disease.* Clinical symptoms. Bacteriological examination of the lesions or discharges from the tonsils and nasopharynx may be useful.

2. *Isolation.* During the clinical course of the disease and convalescence, and particularly exclusion of the patient from participation in the production or handling of milk products.

3. *Immunization.* None.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* Articles soiled with discharges from the nose and throat of the patient.

6. *Terminal Disinfection.* Cleaning.

Military and Naval. No measures differing from those heretofore mentioned are necessary to prevent this disease among soldiers and sailors.

Common Colds

Definition. A group of acute infections of the mucous membranes of the nose, pharynx, tonsils, larynx, trachea, or larger bronchi. A common cold is not merely a congestion or inflammation of the upper respiratory tract, such as frequently occurs as a result of chemical and mechanical irritants other than bacteria.

Geographical Distribution. The known inhabited world.

Predisposing Conditions. Exposure to draughts, sudden changes of temperature, chilling of the body, breathing dusty and vitiated air.

Infectious Agents. The bacteria usually found associated with these catarrhal conditions are: staphylococci, streptococci, pneumococci, influenza bacillus, the Gram negative cocci classed together as members of the micrococcus catarrhalis group, diphtheroid bacilli, *Bacillus catarrhalis,* and other germs. The etiological relationship between these organisms and the disease is not always clear. Many of the above-mentioned bacteria are also found normally upon the mucous membranes of the nose, mouth, throat, and upper respiratory passages. Reinfections must, therefore, be common, and predisposing factors which diminish resistance have a special importance. (Rosenau.)

Source of Infection. The discharges from the nose and throat of infected persons and articles freshly contaminated by them.

Dissemination. By direct and indirect contact infection. Common colds occur in epidemics, as do other contagious diseases. All the members of a household are frequently affected. Outbreaks frequently occur in schools, factories, and other places where people are closely associated. The contagiousness and severity of colds vary greatly in different epidemics and in different seasons of the year, depending on the particular organism involved and other factors not well understood. (Rosenau.)

Portal of Entry. Through the nose and throat.

Incubation Period. Variable, depending upon the infecting organism or organisms.

Period of Communicability. Colds are probably most contagious during the early stages.

Prophylaxis. The prevention of colds consists in guarding against the predisposing conditions and avoiding the infection by careful observance of sanitary rules and the practice of cleanliness based upon the modern conception of contact and droplet infection. People with colds should be avoided, especially in street cars, offices, and other poorly ventilated spaces, where the risk of droplet infection through persons coughing and sneezing in one's face is constant.

Lobar Pneumonia

Synonyms. Croupous or fibrinous pneumonia, pneumonitis, lung fever.

Definition. Acute lobar pneumonia is an infectious disease, the chief pathological feature of which is a uniformly diffuse, exudative inflammation of entire portions of one or more lobes of the lung. Clinically it is characterized by chill, marked prostration, and fever which terminates by crisis.

Geographical Distribution. Pneumonia is almost universally distributed. Climate, of itself, has little or no influence. Although it is much less frequent in the tropics, it is often seen there, especially among the inhabitants of plateau regions. It is frequent all over temperate Europe, and in the inhabited portions of the South Temperate Zone, such as Australia, parts of South America, and South Africa.

Predisposing Conditions. Intimate contact among individuals in limited communities such as military camps, schools, prisons, and on shipboard favors the outbreak of small epidemics.

Some buildings, such as tenement houses, institutions, etc., are endemic foci of pneumonia, probably due to local sanitary conditions. This form may increase in its scope until it assumes an epidemic character. The disease is most frequent in the winter and spring. Exposure to cold lowers local or general resistance, but cannot of itself cause pneumonia. Common colds and other catarrhal conditions render the respiratory passages more than ordinarily susceptible to pneumonic infection. It is frequently seen in those engaged in occupations associated with much dust, which irritates the respiratory mucosa. Injuries and contusions, especially of the chest, predispose to pneumonia by lowering the resistance of the tissues.

Lobar pneumonia occurs at all periods of life, but is more common at the extremes. It occurs frequently in children under six years, less frequently from the sixth to the fifteenth year, and then increases with each subsequent decade.

The North American Indian, the Esquimaux, and the African are more susceptible than the Caucasian race.

It prevails in all walks of life, but is seen more frequently among those living under unhygienic conditions.

Alcoholism and all vicious habits that tend to depress the nervous system and cause the various forms of degeneration of the viscera act as predisposing factors. Chronic diseases such as chronic nephritis, organic heart affections, carcinoma, and diabetes exert a predisposing influence. New arrivals in a country are apparently more susceptible than acclimated natives.

One attack predisposes to others; multiple attacks may occur.

Infectious Agent. Lobar inflammation of the lung may undoubtedly be caused by a number of different bacteria. The vast majority of the lesions, however, are caused by varieties of *Diplococcus pneumoniæ.* Pneumococci are divided into two general classes. The larger of these consists of pneumococci of Types I, II, and III, which comprise about 80 per cent of all strains encountered in disease, and which represent three apparently fixed types of highly parasitic organisms, each possessing common immunologic characters. Individual strains of Type I and Type II are characterized by the possession of immunity reactions common to all other members of the homologous group. A number of variants of Type II pneumococcus have been found, a condition of considerable theoretic interest, the practical importance of which, however, is not sufficiently great to warrant detailed discussion here. Type III consists of *Pneumococcus mucosus,* an organism distinguished from other types by morphological and cultural, as well as immunologic differences, and related to other strains of the same type by common immunologic reactions.

The smaller of these two main classes, which has been called Type IV, represents about 20 per cent of the strains isolated from cases of lobar pneumonia, and is the type most frequently encountered in the mouth secretions of normal individuals. Type IV pneumococci possess greater heterogeneity, and consist for the most part of individual strains that are not interrelated.

The following etiologic agents, commonly found in the nose, throat, and mouth, are concerned in a small proportion of lesions: Friedlander's bacillus, bacillus influenzæ, streptococcus pyogenes, streptococcus mucosus, staphylococcus aureus. Cases of mixed infection with combinations of staphylococcus aureus, Friedlander's bacillus, bacillus influenzæ, streptococcus pyogenes, and streptococcus viridans occur.

Source of Infection. Discharges from the mouth and nose of apparently healthy carriers, as well as of recognized infected individuals, and articles freshly soiled with such discharges.

Dissemination. By direct contact with an infected person, or with articles such as handkerchiefs, towels, and drinking-cups freshly soiled with the discharges from the nose or throat of, and possibly from infected dust of rooms occupied by, infected persons.

Portal of Entry. The infecting organisms enter the system through the mouth and nose.

Incubation Period. Short, usually two to three days.

Period of Communicability. Unknown; presumably until the mouth and nasal discharges no longer carry the infectious agent in an abundant amount or in a virulent form.

Immunity. The human race apparently has some resistance to the infection, else pneumonia would be even more prevalent than it is, and recovery less frequent, as the infectious agents are almost ubiquitous.

The mechanism of such immunity as exists is not well understood. Phagocytosis may be a feature of the process, but at present anaphylaxis is the best explanation.

While it more frequently attacks those predisposed by enfeebling conditions of the body or outside circumstances such as exposure, the strong and robust living under ideal sanitary conditions contribute a large quota of the annual victims of this remorseless malady.

Prophylaxis. General Measures. In institutions and camps, when practicable, people in large numbers should not be congregated closely within doors. The general resistance should be conserved by good feeding, fresh air, temperance in the use of alcoholic beverages, and other hygienic measures.

The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms. Specific infecting organisms may be determined by serological and bacteriological tests early in the course of the disease.

2. *Isolation.* Patient during clinical course of the disease.

3. *Immunization.* None. Vaccines are worthy of further careful trial. The present status of prophylactic inoculation against pneumonia is as follows:

Prophylactic pneumococcus vaccination is successful over an extended period of time for those groups represented in the vaccine.

A pneumococcus lipovaccine, of slight toxicity, to be given at one injection, has been elaborated, and has had widespread use. Early reports indicate its usefulness.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* Discharges from the nose and throat of the patient.

6. *Terminal Disinfection.* Thorough cleaning, airing, and sunning.

Heretofore pneumonia has been regarded too much in the light of a necessary evil, because it is so widely spread, and the determining factors of the infection are not well understood. It should be a notifiable disease and its dissemination checked as much as possible by at least constructive isolation and bedside disinfection. There is no known specific prophylaxis. The disease will not be controlled until such a measure is discovered.

General measures include the spreading of knowledge concerning the disease, enforcing proper building and housing laws, and regulations governing the ventilation and care of places of public assembly such as theaters, schools, public buildings, and street cars. A strict compliance with anti-spitting regulations must be required, and the streets must be properly cleaned and cared for to prevent irritating dust.

In the light of our present knowledge personal preventive measures consist of avoiding, as far as possible, the infection and the predisposing conditions by the observance of the dictates of general and personal hygiene, especially those that tend to prevent infection from person to person through the secretions of the mouth and nose. This code includes refraining from promiscuous kissing and expectoration, covering the nose and mouth with the handkerchief when coughing and sneezing, avoiding the common drinking-cup and roller towel, and refraining from putting unnecessary things in the mouth.

Sleeping with open windows or on a sleeping-porch, the regulation of the temperature and ventilation of living and working rooms and shops, and the habitual use of the cold bath in the morning tend to prevent pneumonia and many other diseases, especially those of the respiratory tract.

It is possible for every one to avoid some of the predisposing conditions of pneumonia, such as dissipation and other excesses, but unfortunately most people in all walks of life are unavoidably exposed to one or more factors, such as worry, poor or insufficient food, overwork, lack of exercise, loss of sleep, living and sleeping in overheated rooms with excessively dried air. The remedies are obvious, but will come only with the millennium.

In view of the fact that only certain types of lobar pneumonia have been shown to be communicable, public health laboratories should be equipped to determine the type of pneumococcus responsible for each particular case of the disease. Additional data concerning its epidemiology would then be available.

Recent studies have shown that a large percentage of pneumonia patients contaminate the rooms which they occupy, as is shown by the large number of instances in which strictly pathogenic types of pneumococcus can be recovered from the dust of these apartments. This indicates the thorough cleansing of any room occupied by a case of pneumonia at the close of the period of convalescence. In addition, the daily cleansing of the sick-room should be practiced in such a way as to avoid dissemination of dust.

Military. Pneumonia often occurs among soldiers, and under certain circumstances (overcrowding in barracks) tends to become epidemic. As it is transmissible and has a high mortality, all possible precautions should be taken on the appearance of a case to prevent its spread.

METHODS OF CONTROL. 1. The prevention of overcrowding.

2. Education of the men to avoid contact infection, direct and indirect.

3. Take measures to reduce the amount of dust in camp. There is a possibility that pneumonia may be carried by dust. Even if this is not true, other diseases are carried by dust.

4. Increase the resistance or vital tone of the men by living a normal life as far as circumstances will permit.

5. Prompt notification of cases just as with other communicable diseases.

6. Classification as to type of organism in the laboratory. Send the sputum to the nearest department laboratory.

7. Isolation of the cases in hospital and adoption of medical asepsis and bedside disinfection. As an additional factor of

safety the isolation of the patient should continue as long as he harbors the virulent type of pneumococcus. The sputum of convalescents may be sent once a week to the nearest laboratory until a negative report is obtained, after which the patient may be returned to duty.

8. Whenever possible, deal with the problem of carriers. The sputum of all contacts may be sent to the laboratory, and if virulent types of pneumococci are found, they may be isolated if thought desirable until a negative report is obtained.

Naval. The sanitary procedures effective in preventing the spread of pneumonia under military conditions have equal value in preventing and controlling the disease in naval training stations, navy yards, and marine barracks.

Living conditions aboard ship are such that more or less overcrowding is unavoidable, therefore the men must be carefully instructed regarding the dangers of contact infection. When cases develop they must be isolated, and bedside disinfection practiced. If laboratory facilities are available carriers of virulent types of pneumococci should be searched for and isolated when found. The sputum of convalescents should be examined weekly, and their return to duty governed by the laboratory findings. The deck of the sick bay or other compartment where pneumonia patients are isolated should be cleansed and disinfected daily. Cases should be transferred to a hospital ship or naval hospital at the earliest available opportunity.

Cerebrospinal Fever

Synonyms. Cerebrospinal meningitis, spotted fever.

Definition. An acute communicable disease characterized anatomically by inflammation of the meninges of the brain and spinal cord. It runs an irregular clinical course with moderate fever and characteristic and profound nervous symptoms, severe headache, pain in the back and upper part of the spine, contraction of the muscles of the nucha, hyperesthesia, delirium, and frequently coma.

Geographical Distribution. Epidemics of various degrees of severity have been described in almost every part of the world except the tropics. On several occasions it has assumed pandemic proportions. Sporadic cases occur from time to time in all large centers of population, but it can no longer be considered an endemic disease of cities.

Predisposing Conditions. All ages are susceptible, though most cases occur in children and young adults. In common with most diseases in which the infection is disseminated by discharges from the respiratory tract, and which are supposed to be spread mainly by contact, it occurs most frequently in the winter and spring. Rural communities are more afflicted than cities. Epidemics are usually localized. It has been of frequent occurrence in mining districts and seaports. The concentration of human beings, as in barracks, tenement houses, and on ships where contact infection is easy, is a factor. Overexertion, long marches in the heat, and depressing mental and bodily surroundings are predisposing conditions. Before the introduction of modern sanitary methods it was common in barracks, camps, ships, and prisons. In civil life it is now most often seen among the poorer classes living in ill-ventilated and overcrowded habitations.

Infectious Agent. Diplococcus intracellularis (the meningococcus).

Source of Infection. Discharges from the nose and mouth of infected persons. Clinically recovered cases, and healthy persons who have never had the disease but who have been in contact with those having it or with other carriers act as carriers and are commonly found, especially during epidemics. Such healthy carriers are not uncommonly found independent of epidemic prevalence of cerebrospinal fever.

Dissemination. By direct contact with infected persons and carriers, and indirectly by contact with articles freshly soiled with the nasal and mouth discharges of such persons.

The disease is not highly contagious. The meningococcus is of low vitality and quickly succumbs to light and drying; therefore, the transmission must be rather direct from person to person. Doubtless the germ is passed from one carrier to another until a non-immune receives the infection and the disease results. It is highly probable that cerebrospinal fever is transmitted principally through the medium of healthy carriers by droplet infection.

Portal of Entry. The organism probably enters the system through the mucous membrane of the naso-pharynx, from which it reaches the meninges through the lymphatic connections which extend along the olfactory nerves, or indirectly by way of the blood.

Incubation Period. Two to ten days, commonly seven. Occasionally the period is longer when a person is a carrier for a time before developing the disease.

Period of Communicability. During the clinical course of the disease and until the specific organism is no longer present in the nasal and mouth discharges of the patient or of healthy carriers as far as persistence of infectious discharges is concerned.

Immunity. Man evidently has considerable natural immunity to this infection, as only a small proportion of healthy carriers ever develop the disease. Permanent immunity is rarely conferred by an attack. Relapses are common and second (recurrent) attacks have been occasionally observed.

Prophylaxis. General Measures. 1. Search for carriers among families and associates of recognized cases by bacteriological examination of posterior nares of all contacts.

2. Education as to personal cleanliness and necessity of avoiding contact and droplet infection.

3. Prevention of overcrowding, such as is common in living quarters, transportation conveyances, working places,

and places of public assembly in the civilian population, and in inadequately ventilated, closed quarters in barracks, camps, and ships among military units.

The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms, confirmed by the microscopic and bacteriological examination of the spinal fluid, and by bacteriological examination of nasal and pharyngeal secretions.

2. *Isolation* of infected persons and carriers until the nasopharynx is free from the infecting organism, or, at the earliest, until one week after the fever has subsided.

3. *Immunization* may prove of value. Immunization by the use of vaccines is still in the experimental stage.

4. *Quarantine.* None.

5. *Concurrent disinfection* of discharges from the nose and throat and of articles soiled therewith.

6. *Terminal Disinfection.* Cleaning.

Briefly, the conditions influencing the prophylaxis of cerebrospinal fever are as follows: We know what preventive measures are indicated, but they are most difficult, if not impossible, of practical application. According to reliable estimates there are ten times more healthy carriers than recognized cases. Obviously it would be impossible in a community of any size to discover all these by bacteriological examination, and also impossible to isolate or control them after discovery by any authority short of martial law. However, such carriers as are discovered should be kept under observation and treatment and carefully instructed as to the dangers of contact and especially droplet infection. They should be impressed with their grave danger to their fellow men.

Some secondary cases may be prevented by proper sanitary measures taken to prevent the spread of the disease from the recognized and suspected cases. The health department should be promptly notified and the patient isolated. Careful bedside disinfection of the discharges from the nose and throat should be carried out. The house should be placarded and visiting strictly prohibited. The fewer the number of contacts the fewer the number of possible carriers.

Quarantine measures as a rule are ineffective, but localized outbreaks in villages, camps, barracks, ships, or institutions where authority is absolute may be kept from becoming foci of infection by strict isolation.

During epidemics unusual attention should be paid to personal cleanliness. Antiseptic gargles and nasal douches should be frequently employed. Crowds should be avoided, also the use of public drinking-cups, towels, etc. If the epidemic is severe, the schools should be closed.

It is impracticable to use antimeningitis serum as a preventive, as it must be introduced into the subdural space by lumbar puncture.

Military. Cerebrospinal fever occurs in sporadic and epidemic form, usually in the winter and spring. Overcrowding is the chief predisposing factor. The troops most frequently affected are those living in barracks, garrisons, towns, and camps. Those in the field suffer less frequently.

METHODS OF CONTROL. 1. *Prompt Diagnosis.* Lumbar puncture should be made early in a suspected case. Camp hospitals should be equipped to make the simple stains necessary, and may also, if practicable, make cultures from the spinal fluid on blood serum or blood agar. Early diagnosis is important, as it enables steps to be taken promptly to isolate contacts and possible carriers.

2. *Isolation of Contacts.* All men in the same tent or room may be considered to be contacts, together with any other men with whom the patient has been intimate. When a case has occurred it is quite usual to find that several men in the same squad are infected and will either develop the disease or become healthy carriers. These men should be placed in a detention ward and watched until all danger of an epidemic

is past, or until swabs have shown the absence of meningococci in the nasopharynx.

3. Isolate the patient in a separate room in the hospital or in a tent and practice careful medical asepsis and bedside disinfection. A carbolic mouth wash and an antiseptic spray for the nose may be used.

4. Laboratory facilities and skilled bacteriologists are essential in combating cerebrospinal fever. Lieutenant Colonel E. B. Vedder, Medical Corps, U.S.A., in his valuable manual, "Sanitation for Medical Officers," describes as follows the procedures when such facilities are available:

"I. Cultures from both spinal fluid and nasopharynx of cases to determine the type of organism.

"II. Examination of the nasopharynx of all contacts to detect carriers. This may be done by means of swabs, which should be plated at once as soon as the swab is taken, and the single colonies that develop can be tested in about twenty-four hours with immune serum to determine not only whether the meningococcus is present, but to determine the type. If the type of organism found in the contacts is the same as that found in the patient, no other source of infection need be suspected. However, should types be found other than those found in the patient, other carriers must be present and should be searched for. This may be done by examining the contacts of the contacts. This necessarily entails a large amount of work, as during an epidemic 10 per cent of the men may be carriers.

"III. All carriers to be isolated until negative swabs can be obtained. All men not carriers to be released at once.

"IV. Treatment of carriers to remove infective organisms."

Naval. In the navy most of the cases of cerebrospinal fever occur among the unseasoned men and boys at the training stations, where the problem is the same as that confronting the military sanitarians at the army camps and cantonments.

Afloat, the preventive measures effective against pneumonia, diphtheria, and other diseases of the respiratory type are likewise applicable to cerebrospinal fever. Prompt diagnosis, isolation, and bedside disinfection of cases and the detection, treatment, and disposition of carriers are the essential points at sea as on shore.

Poliomyelitis

Synonyms. Infantile paralysis, atrophic spinal paralysis, essential paralysis of children, acute anterior poliomyelitis.

Definition. An acute, communicable disease occurring both in epidemics and sporadically, characterized anatomically by widespread lesions of the nervous system, often localizing, especially in the anterior horns of the gray matter of the spinal cord.

Geographical Distribution. Sporadic cases of the disease have been reported from various parts of the world during the past century. Up to 1907, the large epidemics were confined to Scandinavian countries; since 1907, large epidemics have occurred in most civilized countries. In 1916 a severe epidemic visited the United States.

Predisposing Conditions. The disease attacks without discrimination all classes; the lowly and the well-cared-for are alike susceptible. The great majority of cases occur in children under five years of age. Epidemics have been more severe and the case rate has been higher in small towns and sparsely settled districts than in centers of dense population. In cities the crowded districts are not especially affected. Cold countries with marked seasonal variations of temperature have suffered the most, but the disease is always most prevalent in the dry months, from May to November in the Northern Hemisphere and November to May in the Southern Hemisphere. Sporadic cases occur throughout the entire year.

Infectious Agent. A filterable and cultivable virus, *Flexneria noguchii.* (Barker.)

Source of Infection. Nose, throat, and bowel discharges of infected persons, or articles recently soiled therewith. Healthy carriers are supposed to be common.

Dissemination. By direct contact with an infected person or with a carrier of the virus, or indirectly by contact with articles freshly soiled with the nose, throat, or bowel discharges of such persons.

As the virus resists drying, it is possible that it may be spread by fomites that have been contaminated by a person sick of the disease, or by a healthy carrier.

Rosenau, Anderson, and Frost demonstrated experimentally that the virus may sometimes be transmitted from monkey to monkey by the stable fly (*Stomoxys calcitrans*), but the rôle of insects in the transmission of the disease is still undetermined.

Portal of Entry. In all likelihood, the lymphatic tissue of the mouth, throat, nose, and pharynx, possibly also of the intestine.

Incubation Period. From three to ten days, commonly six days.

Period of Communicability. Unknown; apparently not more than twenty-one days from the onset of the disease, but many cases have healthy carrier periods before the development of clinical symptoms and many convalescents become carriers.

Prophylaxis. General Measures during Epidemics. 1. Search for and examination of all sick children should be made.

2. All children with fever should be isolated pending diagnosis.

3. Education in such technique of bedside nursing as will prevent the distribution of infectious discharges to others from cases isolated at home.

The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms, assisted by chemical and microscopical examination of the spinal fluid.

2. *Isolation* of all recognized cases in screened rooms.

3. *Immunization.* None.

4. *Quarantine* of exposed children of the household and of adults of the household whose vocation brings them into contact with children, or who are food handlers, for fourteen days from last exposure to a recognized case.

5. *Concurrent Disinfection.* Nose, throat, and bowel discharges and articles soiled therewith.

6. *Terminal Disinfection.* Cleaning.

Influenza

Synonyms. La grippe, epidemic catarrh.

Definition. An acute, highly contagious disease characterized by catarrh of the respiratory and digestive tracts, profound muscular and nervous prostration, and grave complications and sequelæ.

Geographical Distribution. The prevalence of influenza has no relation to climate or meteorological conditions except sunshine, the worst epidemics having been in the coldest seasons of the year. The pandemic of 1889 and 1890 started in Central Asia and spread to every part of the world, including the Arctic regions. The pandemics have usually spread from east to west.

Predisposing Conditions. Persons of all ages and conditions of life are liable to infection. The period of greatest susceptibility is the third decade of life. Infants are the least susceptible. Elderly persons and those of low vitality due to chronic maladies or neuropathic heredity succumb among the first.

Infectious Agent. *Bacillus influenzæ.*

Source of Infection. Secretions of the nose, throat, and respiratory tract and articles, such as handkerchiefs, *freshly* contaminated by them.

Dissemination. Influenza is spread by direct and indirect contact, chiefly by droplet infection. It is very contagious, especially in the early stages. Freshly contaminated objects readily transmit the disease. Carriers are common and keep influenza alive between epidemics.

It spreads with remarkable rapidity, but only as fast as modern railway and steamship transportation, thus disposing of the theory of widespread aerial dissemination.

As the germ does not multiply outside the body and has a very feeble resistance, the transmission of influenza by fomites is improbable.

Incubation Period. This is quite brief, seldom exceeding two or three days.

Period of Communicability. During the entire course of the disease; doubtless in many cases there is a healthy carrier stage before the development of clinical symptoms. Some convalescents become carriers and disseminate the disease for months.

Immunity. There is little natural immunity to influenza, one attack predisposing to others, and new infections and reinfections are common. The apparent greater susceptibility of males and robust persons is probably due to greater exposure.

Prophylaxis. GENERAL MEASURES. 1. Education of the public as to personal cleanliness, the necessity of avoiding contact and droplet infection, and the danger of the trade in saliva.

2. Prevention of overcrowding in living quarters, working places, places of public assembly, and public transportation conveyances.

THE INFECTED INDIVIDUAL AND HIS ENVIRONMENT. 1. *Recognition of the Disease.* Clinical symptoms, possibly confirmed by bacteriological examination of secretions from the nose and throat.

2. *Isolation.* Of little value, because many cases have a healthy carrier stage before the development of clinical symptoms and many convalescents become carriers.

3. *Immunization.* None.

4. *Quarantine.* The local quarantine of institutions, prisons, etc., is sometimes of value.

5. Concurrent disinfection of discharges from the nose and mouth and of articles soiled therewith.

6. *Terminal Disinfection.* Cleaning.

The available preventive measures against influenza are practically the same as those against the other diseases spread by oral and nasal secretions, and they are generally futile. A national quarantine is not practicable, on account of the large number of mild and unrecognized cases and carriers. Local quarantines of institutions, prisons, etc., were successful during the great pandemic of 1889-90. The first case of influenza in a house, institution, barracks, or the like should be isolated in the hope of checking its further spread.

During the present pandemic of influenza numerous vaccines, some containing *Bacillus influenzæ,* the four types of pneumococci, *Streptococcus hæmolyticus* and *Staphylococcus pyogenes aureus* were used. The evidence does not show that any protection was afforded by their use.

Military and Naval. Methods of Control. 1. Prevention of overcrowding.

2. Protection of the men from extremes of temperature; other general hygienic measures, especially good ventilation, to maintain the health of the command.

3. When cases resembling influenza appear in a camp, barracks, cantonment, garrison, station, or on a ship, the higher sanitary authorities should be notified of the fact, as influenza is a dangerous epidemic disease.

4. Many cases of common colds are sufficiently severe to resemble influenza, therefore before reporting cases as influ-

enza an attempt should be made to verify the diagnosis by isolating the *Bacillus influenzæ.*

5. Isolate patients in hospital or tents.

6. If cases are few, contacts may be isolated in detention camps in small groups for four days. If influenza does not develop, they may be released. If cases are numerous, this procedure would be of little value.

The unavoidably intimate association of the personnel of armies in present-day warfare makes the prevention and control of influenza, once it gains a footing, almost if not quite impossible.

The Pandemic of Influenza of 1918-19

The origin of the great pandemic which in 1918-19 swept the world is generally attributed to Spain, hence the name "Spanish influenza." It is doubtful, however, whether the disease was first seen in Spain or in North America. It appeared on both continents in a mild form early in the spring of 1918. Some claimed that it was brought to Spain by the German U-boats and spread to the civil population from the interned crews. Others hold that it was brought to the Western Hemisphere from China by the coolies of the Chinese Labor Corps serving in the French and British Armies. In the latter part of March it appeared in the American Expeditionary Force in France and in the French and British Armies and in the civil population. It soon spread to the British Isles, Holland, and the Scandinavian countries. The death rate was low. Major Soper, S.C., U.S.A., states that the first cases in Germany were among troops that fought with an American regiment (presumably infected). The disease has spread across the American continent, to the islands of the Pacific, to South America, to North and South Africa, and to the Antipodes.

As the season advanced it assumed a more serious character, being complicated with bronchopneumonia and septic pneumonia, with a high mortality in some of the epidemics. The first cases of the highly virulent type of the infection seen in America were among sea-faring men. Throughout the summer a number of ships arrived at Atlantic ports with many cases of influenza on board. In some of the outbreaks there was a great deal of a fatal pneumonia. The patients from these ships were sent ashore and, mingling with the civilian population along the entire Atlantic coast, doubtless thoroughly disseminated the infection.

The supposition has been advanced that the marked virulence noted in the latter months of the pandemic is, in some way not determined, due to the weather, the mild influenza of the spring having become greatly intensified in the autumn.

The consensus of opinion is that the bacillus of Pfeiffer, *Bacillus influenzæ,* is the specific causative agent, but that most cases are mixed infections. Presumably something must have happened to increase the virulence of the bacillus, or a new and more active strain of it has appeared, or the susceptibility of those attacked has become increased. Some state that the causative agent has not been discovered, and that the bacillus of influenza is not really responsible for the disease. It is even claimed by some that the disease is not influenza. The most interesting hypothesis is that advanced by Captain J. J. King, M.C., U.S.A. His arguments are briefly as follows: There is a striking similarity in the present epidemic to the epidemic of pneumonic plague which broke out at Harbin, China, in October, 1910, and spread rapidly and continuously throughout Northern China at that time, especially following the lines of railroad traffic. From that time until the present China has not been free from the plague. In 1917 a large number of Chinese coolies were brought from China to Europe to serve in the Chinese Labor Corps, some being transported through the Mediterranean and some across North America. Many were captured in the German drive on the Western Front in March, 1918. Captain King and others maintain that the present epidemic started in the German

Army last spring, and that it is not influenza, but a modified form of the pneumonic plague carried into the German lines by the Chinese prisoners. In the Chinese epidemic the cases presented at the outset few definite symptoms except general malaise, prostration, loss of appetite, etc., the same as in the recent epidemic. The outstanding features of the Chinese epidemic were high infectivity and high mortality. The recent epidemic of influenza was characterized by a greater degree of infectivity, more frequent pneumonic complications, and greater mortality than any previously recorded epidemic.

In the pneumonic plague of China the *Bacillus pestis* is almost constantly associated with the pneumococcus and streptococcus, different strains of the same organisms being found in different localities. The bacteria of the recent epidemic were *Bacillus influenzæ* associated with the four groups of pneumococci, the *Streptococcus hæmolyticus* and *Micrococcus catarrhalis,* varying in different parts of the world. We therefore see two epidemics, varying in mortality and virulence in different localities, each caused by a bacillus associated with different strains of pneumococci and streptococci. The influenza bacillus and *Bacillus pestis* in atypical forms may simulate each other. The organisms may assume different forms and have different cultural characteristics under different conditions. The ordinary influenza bacillus is short and slender, while the plague bacillus is about the same length but is generally fatter and broader; they are both Gram negative. It seems possible that the plague bacillus may have been present in a non-virulent state in the Chinese coolies and assumed a new virulence, vigor, and somewhat different form when transplanted to virgin soil, *viz.,* the German soldiers to whom the Chinese carriers transmitted the organisms. The high mortality and infectivity of this epidemic strongly suggest this possibility. In view of the foregoing it is not beyond the realms of possibility that the two diseases are the same.

Captain King's hypothesis offers an explanation of the epidemics that have followed all great wars. If a nation or tribe can survive any disease long enough it will acquire immunity to that disease. When, however, foreign people commingle freely and intimately, as in war, epidemics will break out. The inactive, virulent organisms in one race will become virulent in some other race which has not acquired immunity to that specific organism.

This pandemic will go down in history as one of the greatest that has ever visited the world. It has caused a greater loss of life than the Great War, and its victims have been largely drawn from the same productive period of life.

Chapter II

THE FECAL-BORNE DISEASES

Typhoid Fever

Synonyms. Enteric fever, gastric fever, nervous fever, ileo-typhoid fever, pythogenic fever, low fever, typhus abdominalis.

Definition. An acute infectious disease characterized clinically by a gradual onset, peculiar temperature curve, swelling of the spleen, rose-colored spots, tympanites, sero-reaction, and a liability to intestinal hemorrhage and perforation. It is a bacteremia, its most frequent local manifestations being a hyperplasia and sloughing of Peyer's patches and the solitary follicles of the intestines and parenchymatous changes in the principal viscera.

Predisposing Conditions. In the North Temperate Zone it is most prevalent in late summer and early autumn. Young, robust individuals, between the ages of fifteen and thirty, are most frequently attacked. Intestinal catarrh, great mental excitement, and overwork predispose to the disease. The male sex is rather more frequently affected.

Infectious Agent. *Bacillus typhosus.*

Source of Infection. Bowel discharges and urine of infected individuals. Healthy carriers are common.

Dissemination. Until recently typhoid fever was considered to be essentially an intestinal disease, and to be caused by infected food or drink. It is now known to be a systemic infection, some cases presenting no intestinal symptoms, the feces being free from bacilli during the whole illness. This has caused us to modify our views of the dissemination of the disease. Formerly great importance was placed on air infection; this later gave place to a tendency to attach undue weight to water and milk infection, probably because of the sensational character of some of the outbreaks and the thoroughness with which they were studied.

The most careful observers now see in contact infection, direct or indirect, the cause of outbreaks in families, institutions, military forces, on shipboard and in other communities where people are in close and continuous personal contact. Direct or indirect contact infection from walking, missed, or unrecognized cases and carriers and the infection of food by the contaminated fingers of nurses and patients are responsible for a large proportion of cases.

Only a small part of the typhoid in this country can be traced to infected water. Undoubtedly in some cities a large part of it is due to this cause, but this is not so in most instances. Outbreaks originally due to infected water and milk have been continued by contact infection.

Infected shellfish, celery, etc., play an unimportant part in the dissemination of typhoid. Air-borne or dust-borne infection is of little moment, especially in civil life.

Infection by means of flies is an important factor in military, mining, construction, and lumber camps, and in fact in any community such as the small country village and rural districts with exposed outdoor closets. There is little to be feared from *Musca domestica* in any community or institution, rural or urban, which has decent sanitary arrangements.

Portal of Entry. In the vast majority of cases the bacilli are swallowed. There is a possibility of infection through the tonsils.

Incubation Period. From seven to twenty-three days, averaging ten to fourteen days.

Period of Communicability. From the appearance of prodromal symptoms, throughout the illness and relapses during convalescence, and until repeated bacteriological examinations of the discharges show persistent absence of the infecting organism. In the case of carriers this may last for months or years, especially if the bacilli become established in the gall bladder.

Immunity. Permanent immunity generally follows an attack of typhoid fever, though many instances of two and some of three attacks are recorded.

Paratyphoid Fever

Definition. This term is applied to a group of affections that closely simulate typhoid fever clinically, but are due to different microbic causes.

Predisposing Conditions. About the same as true typhoid fever.

Infectious Agents. *Bacillus paratyphosus A* or *B*.

Source of Infection. Bowel discharges and urine of infected persons, and food contaminated with such discharges of infected persons or of healthy carriers. Healthy carriers may be numerous in an outbreak.

Dissemination. Directly by personal contact; indirectly by contact with articles freshly soiled with the discharges of infected persons or through milk, water, or food contaminated by such discharges.

Portal of Entry. The digestive tract.

Incubation Period. Four to ten days; average, seven days.

Period of Communicability. From the appearance of prodromal symptoms, throughout the illness and relapses, during convalescence, and until repeated bacteriological examination of discharges show absence of infecting organism.

Bacillus enteritidis and *Bacillus suipestifer*, closely allied to the paratyphoid group of organisms, are responsible for clinical pictures resembling typhoid and paratyphoid fevers. They are disseminated by food contaminated in preparation, sometimes at least, by human carriers.

Bacillary Dysentery

Definition. A form of intestinal flux, usually of an acute type, occurring sporadically and in severe epidemics, attacking children as well as adults, characterized by pain, frequent passages of blood and mucus, and due to the action of a specific bacillus, of which there are various strains.

Geographical Distribution. Most of the great epidemics of dysentery that have been recorded have occurred in temperate climates and were, in all probability, of the bacillary variety. This is true of the epidemic dysentery of armies in temperate climates and the epidemic dysentery of public institutions such as asylums for the insane. Epidemics of bacillary dysentery have occurred and do occur in the tropics. Small outbreaks, generally bacillary, occur among the civil population in countries with temperate climates. Various strains of the bacillus are found all over the world in cold, temperate, and warm climates, especially the latter. In temperate climates the germs probably cause a type of the infantile diarrheas. In the tropics the epidemics of bacillary dysentery occur more frequently at the end of the dry and the beginning of the wet season.

Predisposing Conditions. Warm climates, the summer months in temperate climates, insufficient and coarse food, catarrhal conditions of the intestines, conditions of lowered vitality induced by chill, exhaustion, malaria, scurvy, etc. It is sure to appear in epidemic form during times and conditions of war and famine. It is especially common among large aggregations of people (army camps, refugees, pilgrimages, festivals, etc), particularly in the tropics.

Infectious Agent. *Bacillus dysenteriæ.*

Source of Infection. The bowel discharges of infected persons. Healthy bacillus carriers are often observed.

Dissemination. By drinking contaminated water, by eating infected foods, and by hand to mouth transfer of infected material; by objects soiled with discharges of an infected individual or of a carrier; by flies. Direct contact infection is more common than infection by polluted water, milk, or other food. Mild infections, in ambulant patients, are especially dangerous to other individuals.

Portal of Entry. The alimentary canal, almost invariably via the mouth. Very rarely through the rectum by soiled clothing or instruments.

Incubation Period. Two to seven days.

Period of Communicability. During the febrile period of the disease and until the organism is absent from the bowel discharges.

Amebic Dysentery

Synonyms. Bloody flux, intestinal amebiasis, amebic enteritis.

Definition. A colitis, usually chronic, though it may be acute, often leading to abscesses of the liver.

Geographical Distribution. Amebic dysentery is generally distributed throughout the tropics and subtropics. It is endemic in Africa, especially Senegambia, Algeria, and Egypt; in Asia it occurs particularly in India, Indo-China, China, and the Philippines. It is rare in Central America, the West Indies, and the Guianas, but common in Brazil and Chili. The disease is endemic in Russia, Germany, Italy, and the Southern United States.

Predisposing Conditions. The same as bacillary dysentery.

Infectious Agent. *Entamœba histolitica.*

Source of Infection. The bowel discharges of infected persons.

Dissemination. By drinking contaminated water, by eating infected foods, and by hand to mouth transfer of infected material; by objects soiled with discharges of an infected individual, or of a carrier; by flies.

The principal source of the dysenteric germs is most probably the drinking water. The disease is feebly communicable by contact. The rat has been suggested as a possible or probable disseminator of dysenteric amœbæ pathogenic for man.

Portal of Entry. The alimentary canal.

Incubation Period. Unknown.

Period of Communicability. During course of disease and until repeated microscopic examination shows absence of *Amœba histolitica.*

Cholera

Synonyms. Asiatic cholera, Indian cholera, spasmodic cholera, cholera infectiosa, cholera algida.

Definition. Cholera is an acute, infectious, epidemic disease, characterized by copious watery dejections, painful cramps, collapse, and suppression of the urine.

Geographical Distribution. The original home of cholera is in Asia, but it is now a cosmopolitan disease that does its greatest damage in warm countries. All the pandemics and many of the epidemics have been traced back to the fountainhead. Very few places which lie along the highways of commerce and travel have escaped. No place in the civilized world is exempt, and only high regard for and strict attention to hygiene, sanitation, and quarantine will protect a locality. Some of the colder regions of the earth have escaped, due to climatic conditions unsuitable for the propagation of the disease. Tropical and Southern Africa have not yet been infected. Certain islands, among others Réunion, the Andaman, and the Azores, possibly because of their relative isolation, or to precautionary measures, have so far escaped the visitation of cholera.

The disease is endemic in Lower Bengal and the Delta of the Ganges. There is evidence that seems to show that it is also endemic in Bangkok, Canton, and Shanghai, and probably in the Philippines, becoming epidemic from time to time. In temperate climates and in Russia it becomes epidemic, as a rule, only in warm weather, subsiding in winter and often reappearing with the return of higher temperatures, apparently without fresh introduction.

Manson says, ". . . Cholera reaches Europe by three distinct routes: I, via Afghanistan, Persia, the Caspian Sea, and the Volga Valley; II, via the Persian Gulf, Syria, Asia Minor, Turkey in Europe, and the Mediterranean; III, via the Red Sea, Egypt and the Mediterranean."

Predisposing Conditions. Warm climates and seasons, low altitudes, especially the seacoast; alcoholic and dietetic excesses and the ingestion of anything tending to cause gastrointestinal catarrh, such as unripe and overripe fruit, melons, cucumbers, salads, shellfish; fatigue, chill, old age, male sex slightly more than female; filthy surroundings; personal uncleanliness, overcrowding, insufficient shelter and clothing.

The Negro is very susceptible; the Chinese relatively insusceptible.

Infectious Agent. *Spirillum choleræ asiaticæ.*

Source of Infection. Bowel discharges and vomitus of infected persons, and feces of convalescent or healthy carriers. Ten per cent. of contacts may be found to be carriers.

The disease is localized in the intestine, never in the blood or tissues. The bacilli frequently enter between the basement membrane and the epithelial cells and aid in the detachment of the latter. Cholera is a toxemia.

Dissemination. The disease is transmitted by human beings along the lines of human intercourse by sea and land and by surface water courses. Water and food are contaminated by the discharges of patients, or mild, abortive, "missed," unrecognized, undiagnosed cases or by convalescents or carriers. The means by which water and food may become contaminated are numerous, the central water supply may become infected, as at Hamburg in 1892, or the wells, surface watercourses, etc., may become polluted by defecation, washing, bathing, etc., in and around them, as in the Philippines in 1902. Food may become contaminated by watering growing garden truck, as lettuce, with infected water, or by fertilizing the soil with human feces as is done in the Far East. Food may be washed with infected water preparatory to eating. Cooked food is infected by the contaminated hands of servants and others, some of whom may be carriers or whose hands may have become directly or indirectly contaminated by the feces or vomitus of patients, convalescents, missed cases, etc. Eating from a common vessel with the hands, as practiced by the Filipinos and other Asiatics, may and does spread cholera. Handling of food and betel-nut leaves by dealers and prospective purchasers is a means of transmission. Infection of food brought from infected districts was apparently not very frequent in the Philippines; recent contamination seems essential to infection.

There is little danger of a general cholera infection due to an infected water supply in places where modern sanitary conditions exist and sanitary laws are enforced. There is no danger of spread by fomites except by clothing and other articles directly and recently contaminated by intestinal discharges and vomitus.

The danger is not so much from typical cases, which are easily detected, but from mild ones, carriers, etc.

Cholera may appear in the form of a simple diarrhea or in a more obscure manner, simulating some other infection.

The conditions for infection by contact in the cholera infested countries of Asia are ideal. The opportunities for the direct transference of fecal matter from person to person are far greater than in Europe or America. The filthy habits, ignorance or disregard of personal hygiene, and the conditions of overcrowding in habitations played a more important rôle than infected water in the Philippine epidemics.

Crowded quarters on shipboard and in barracks and camp present many opportunities for infection by direct and indirect contact with the hands of carriers, convalescents, and missed cases, and with articles contaminated by them.

Explosive outbreaks on shipboard are probably due to infected drinking-water supply.

It is disseminated by flies and other insects coming in contact with the intestinal discharges or vomitus of patients, carriers, and others which contain the spirilla. The flies then convey the germs mechanically to food such as milk, cooked meat, fruit, etc., which has escaped infection by other means.

Epidemiological evidence is strongly against the existence of the bacilli in the soil though they may survive in dust three days and in air one day. Under natural conditions in unsterilized materials the life of the organism is quite short. It probably cannot increase in numbers outside the body. It is destroyed by the simultaneous growth of other organisms in unsterilized water.

The disease is maintained during intervals between epidemics by mild, unrecognized cases, latent infections, and carriers.

Moderate rains appear to disseminate the spirilla and heavy rains to carry them off.

Portal of Entry. The gastro-intestinal canal.

Incubation Period. One to five days, usually three days, occasionally longer if the healthy carrier stage, before development of symptoms, is included.

Period of Communicability. Usually seven to fourteen days or longer, and until the infectious organism is absent from the bowel discharges.

Immunity. This is conferred by a previous attack of cholera for only a relatively short time.

Ancylostomiasis

Synonyms. Hookworm disease, uncinaiiasis, Egyptian chlorosis, miner's anemia, tunnel worker's anemia.

Definition. A toxemia resulting in a progressive anemia, caused by two species of the hookworm, viz., *Ancylostoma duodenale,* the Old-world form, and *Necator americanus,* the New-world form.

Geographical Distribution. The infection belts the earth in the tropical and subtropical countries with a zone about 66° wide, extending from parallel 36 north to parallel 30 south latitude. In China, India, Ceylon, and Egypt the amount of the infection is very great, ranging from 50 to 90 per cent of the population. In parts of northern South America 90 per cent of the population is infected. The Porto Rico Anemia Commission found that 90 per cent of the rural population of that island were infested. In many of the tropical islands of the Pacific, especially Samoa, the infestation is heavy. Stiles estimated that 2,000,000 people in the South Atlantic and Gulf States harbor the parasite. It is common among the miners in California. It is not endemic in the colder countries, except in mines, especially those of Wales, Germany, Netherlands, Belgium, France, and Spain.

Predisposing Conditions. Soil pollution, personal uncleanliness, going barefooted. Those working in the soil in infested regions, such as agricultural laborers, miners, and tunnel workers, are especially predisposed.

Source of Infection. Feces of infested persons.

Dissemination. The larval forms pierce the skin, usually of the foot, and passing through the lymphatics to the vena cava and the right heart, thence in the blood stream to the lungs, they pierce the capillary walls and pass into the alveoli. Then they pass up the bronchi and trachea to the throat, whence they are swallowed and finally lodge in the small intestine. Also by drinking water containing larvæ, by eating soiled food, by hand to mouth transmission of the eggs or larvæ from objects soiled with infected discharges.

Portal of Entry. Infection generally takes place through the skin, occasionally by the mouth.

Incubation Period. Seven to ten weeks.

Period of Communicability. As long as the parasite or its ova are found in the bowel discharges of an infested individual. Contaminated soil remains infective for five months in the absence of freezing.

Immunity. None.

Prophylaxis of the Fecal-borne Diseases

General Measures. 1. Purification of public water supplies.

2. Pasteurization of public milk supplies.

3. Supervision of other food supplies, and of food handlers.

4. Prevention of fly breeding.

5. Sanitary disposal of human excreta.

6. Extension of immunization by vaccination so far as practicable.

7. Supervision of carriers and their exclusion from the handling of foods.

8. Systematic examination of fecal specimens from those who have been in contact with recognized cases, to detect carriers.

9. Exclusion of suspected milk supplies pending discovery of the person or other cause of contamination of the milk.

10. Exclusion of water supply, if contaminated, until adequately treated with hypochlorite or other efficient disinfectant, or unless all water used for toilet, cooking, and drinking purposes is boiled before use.

11. Placarding houses occupied by typhoid and bacillary dysentery patients as a warning to prospective visitors.

Personal Measures. Protective inoculation when practicable is the best prophylactic measure for the individual. Care should be used as to the source of water and food supplies. Direct and indirect contact infection must be avoided by the scrupulous practice of personal hygiene, with particular reference to the washing of the hands before meals and avoiding placing except food and drink in the mouth.

Military. Against the fecal-borne diseases the prophylactic measures effective under military conditions are:

Protective inoculations.

Proper disposal of human and animal excreta and kitchen waste.

Cleanliness of camp, cantonment, billet, barracks, post, and person.

Protection from flies and their elimination.

Pure water supply and its protection.

Protection of food from contamination.

Early diagnosis of cases and detection of carriers.

Instruction of the men as to the danger of infected water and food and in personal hygiene. Special emphasis must be placed on the washing of hands before meals and after visiting the latrine. In the presence of cholera the men must be warned as to the danger attending contact with the natives and impressed with the importance of clean, short finger nails.

Disinfection.

Naval. When on duty ashore the sailor and marine live under the same conditions as the soldier, therefore the prophylactic measures effective in camps, cantonments, and barracks are of equal value in navy yards, naval training stations, and marine training camps. In addition to the above mentioned methods of control, some of which are obviously applicable to conditions afloat, other precautions, peculiar to sea-faring life, are necessary. These are as follows:

Care in installation of water system aboard ship.

Steam connection for disinfection of pipes.

Constant use of distilled water.

Avoidance of harbor water except in flushing system and fire mains.

Use of sanitary drinking fountain or disinfection of drinking cups in formalin.

Special attention must be given to the disinfection of "heads" and water closets to avoid infection by carriers. The troughs, seats, and decks must be disinfected daily, as the seats and decks may be contaminated from the troughs at the time the excrement is deposited. In cholera-infected ports no shore liberty should be allowed the crew, and only trustworthy men should be sent ashore on duty. These men must carry canteens of boiled water, and drink only this water while on shore.

Typhoid Fever. The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms, confirmed by specific agglutination test and bacteriological examination of blood, bowel discharges, or urine.

2. *Isolation.* In fly-proof room, preferably under hospital conditions, of such cases as cannot command adequate sanitary environment and nursing care in their homes.

3. *Immunization.* Of susceptibles who are known to have been exposed or are suspected of having been exposed. Vaccines are now available whereby immunity to typhoid fever, and to infection with *Bacillus paratyphosus A* and *Bacillus paratyphosus B* may be secured by one series of inoculations.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* Bedside disinfection of all bowel and urinary discharges and articles soiled with them.

6. *Terminal Disinfection.* Cleaning.

Paratyphoid Fever. The Infected Individual and His Environment. The same as typhoid fever.

Bacillary Dysentery. The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms, confirmed by serological and bacteriological tests.

2. *Isolation.* Infected individuals during the communicable period of the disease.

3. *Immunization.* Vaccines give considerable immunity. Owing to severe reactions their use is not universal, nor should it be made compulsory except under extreme emergency.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* Bowel discharges.

6. *Terminal Disinfection.* Cleaning.

Cholera. THE INFECTED INDIVIDUAL AND HIS ENVIRONMENT. 1. *Recognition of the Disease.* Clinical symptoms, confirmed by bacteriological examination.

2. *Isolation* of patient in hospital or screened room.

3. *Immunization* by vaccination may be of value.

4. *Quarantine.* Contacts for five days from last exposure, or longer if the stools are found to contain the cholera bacillus.

5. *Concurrent Disinfection.* Prompt and thorough bedside disinfection of the stools and vomited matter. Articles used by and in connection with the patient must be disinfected before removal from the room. Food left by the patient must be burned.

6. *Terminal Disinfection.* Bodies of those dying of cholera should be cremated if practicable, or otherwise wrapped in a sheet wet with disinfectant solution and placed in watertight caskets. The room in which a patient was isolated should be thoroughly cleaned and disinfected.

GENERAL MEASURES. 1. Rigid personal prophylaxis of attendants by scrupulous cleanliness, disinfection of hands each time after handling patient or touching articles contaminated by dejecta, the avoidance of eating or drinking anything in the room of the patient, and the prohibition of those attendant on the sick from entering the kitchen.

2. The bacteriological examination of the stools of all contacts to determine carriers. Isolation of carriers.

3. Water should be boiled, if used for drinking or toilet purposes, or if used in washing dishes or food containers, unless the water supply is adequately protected against contamination or is so treated, as by chlorination, that the cholera spirillum cannot survive in it.

4. Careful supervision of food and drink. Where cholera is prevalent, only cooked foods should be used. Food and

drink, after cooking or boiling, should be protected against contamination by flies and human handling.

Epidemic Measures. Inspection service for early detection and isolation of cases; examination of persons exposed in infected centers for detection of carriers, with isolation or control of carriers; disinfection of rooms occupied by the sick, and the detention, in suitable camps for five days, of those desirous of leaving for another locality. Those so detained should be examined for detection of carriers.

Anchylostomiasis. The Infected Individual and His Environment. 1. *Recognition of the Disease.* Microscopical examination of bowel discharges.

2. *Isolation.* None.

3. *Immunization.* None.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* Sanitary disposal of bowel discharges.

6. *Terminal Disinfection.* None.

7. *Treatment.* Appropriate of infected individual to rid the intestinal canal of the parasite and its ova.

General Measures. 1. Education as to dangers of soil pollution.

2. Prevention of soil pollution by installation of sanitary disposal systems for human discharges.

3. Personal prophylaxis by cleanliness and the wearing of shoes.

Colonel Bailey K. Ashford, U. S. A., makes the following abstract from "The Control of Hookworm Disease by the Intensive Method," by H. Howard, Director for the International Health Board, West Indies.

More than half the population of the globe lives in infected areas, and permanent agencies are necessary to eradicate the disease. To accomplish this the prevention of soil pollution is the only essential. Disinfection of the soil has been a failure. The International Health Board tries to confine itself to the examination of people infected with the disease and to their treatment and cure. It also participates in education, but the installation and maintenance of latrines is left to local health agencies.

Intensive methods of attacking the disease attempt the complete relief and control of hookworm within a given area. The relief is furnished by treating all infected persons until cured; this is the work of the International Health Board. The control of reinfection is the mission of the local sanitary organization.

The scheme for treating the infected comprises:

1. Mapping the territory, locating roads, streams, villages, houses. Taking a census of the population, numbering the houses, and recording name, age, sex, etc.

2. Examination microscopically of the feces of the entire population.

3. Placing all infected persons under treatment and continuing this treatment until, by standardized microscopic examination, a cure is effected.

4. Public lectures, distribution of literature, house-to-house visits, etc., with general education on the dangers of soil pollution.

Thymol is still the anthelmintic of choice. There are two methods of administration: (*a*) By the daily dose of 10 grains without diet or purge. By this method the reduction in the number of persons infected was from 29 to 31 per cent in an area containing 1918 infected. The work took nine months. (*b*) By the intensive weekly dose of thymol based on an adult dose of 60 grains, with preliminary and subsequent purge of salts. By this method 50 per cent were cured in two treatments. Only a small percentage of infected persons needed more than three treatments. The thymol is finely triturated with an equal quantity of milk sugar before administration and is thus most effective.

The experiments with oil of chenopodium in West Indian colonies have not resulted in its general use. Toxicity is considered its chief drawback.

"The finding of a satisfactory method for the disposal of sewage at the rural home—one which the people may be brought to adopt and to carry out, and which will prove to be safe in actual experience as well as in theory—is a problem yet to be solved."

Chapter III

THE VENEREAL DISEASES

Syphilis

Synonyms. Pox, lues, specific blood poison, the specific disease.

Definition. A chronic infectious disease communicable from person to person by direct and indirect contact with the specific virus and by heredity.

Geographical Distribution. The known world, especially Asia.

Infectious Agent. *Treponema pallidum.*

Source of Infection. Discharges from lesions of the skin and mucous membranes, and the blood of infected persons, and articles freshly soiled with such discharges or blood in which the *Treponema pallidum* is present.

Predisposing Conditions. Impure coitus, alcoholism and debauchery of all kinds, poverty, lack of legitimate forms of amusement.

Dissemination. In the great majority of cases infection is through contact with secretions from the diseased parts during sexual intercourse. Indirectly it may be contracted by contact with the discharges from lesions or with the blood of infected persons. Razors, whistles, musical instruments, dental and surgical instruments, blow-pipes, etc., may act as intermediate agents in indirect contact infection. Physicians and nurses have been infected on the fingers in obstetric and gynecological practice. Infection has followed circumcision, tattooing, cupping, and venesection. Syphilis may be transmitted by vaccination with human lymph which contains the pus of a syphilitic eruption or the blood of a syphilitic person. The initial lesion may appear on the penis, finger, eyelid, lip, tongue, cheek, palate, labium, vagina, cervix uteri, anus, nipple, etc. A person may be a host for syphilis, carry it, give it to another and yet escape it himself. A surgeon may carry the virus under his nails or a woman may have it lodged in her vagina.

Portal of Entry. Syphilis cannot enter through an intact epidermis or epithelial layer. An abrasion or solution of continuity of the skin or mucous membrane is requisite for infection.

Incubation Period. About three weeks. Rare but authentic cases have been reported as long as seventy days.

Period of Communicability. As long as the lesions are open upon the skin or mucous membranes and until the body is freed from the infecting organisms, as shown by microscopical examination of material from ulcers and by serum reactions.

Chancroid

Synonyms. Soft chancre, soft sore, local venereal sore.

Definition. A non-syphilitic venereal sore.

Geographical Distribution. The known world, especially Asia.

Infectious Agent. *Bacterium ulceris chancrosi* (Ducrey).

Source of Infection. The pus or secretion from the chancroid itself.

Predisposing Conditions. Same as syphilis.

Dissemination. Chancroid is almost invariably transmitted through sexual intercourse, though infection by many of the ways mentioned under syphilis does occur, as infection of nurses and physicians during professional manipulations.

Portal of Entry. Minute or gross lesions or abrasions of the skin and mucous membranes.

Incubation Period. Usually within five days, always within ten days.

Period of Communicability. During continuance of specific organism in lesion.

Gonorrhea

Synonyms. Clap, specific urethritis, venereal catarrh, chaude-pisse.

Definition. A contagious, catarrhal inflammation of the genital mucous membrane.

Geographical Distribution. The known world, especially Asia.

Infectious Agent. *Micrococcus Gonorrhœæ.*

Source of Infection. Discharges from lesions of inflamed mucous membranes and glands of infected persons, viz., urethral, vaginal, cervical, conjunctival mucous membranes, and Bartholin's or Skene's glands in the female, and Cowper's and the prostate glands in the male.

Predisposing Conditions. Same as syphilis.

Dissemination. By direct personal contact, usually during sexual intercourse, with infected persons, and indirectly by contact with articles freshly soiled with the discharges of such persons. Females, especially children, may be infected by the use of contaminated towels and linen.

Portal of Entry. The genito-urinary, conjunctival, and rarely the anal mucous membranes.

Incubation Period. One to eight days, usually three to five days.

Period of Communicability. As long as the gonococcus persists in any of the discharges, whether the infection be an old or a recent one.

Venereal Prophylaxis. General Measures. 1. Education in matters of sexual hygiene, particularly as to the fact that continence in both sexes at all ages is compatible with health and development. Knowledge as to the immediate and remote results of venereal infection should be made more common. The ostrich-like prudery of the American public has, in the past, made this very difficult. Pamphlets, illustrated lectures, etc., especially under the auspices of the Y. M. C. A., Boy Scouts, boys' clubs, and similar organizations are efficient means toward this end. The literature of the American Social Hygiene Association, 105 West Fortieth Street, New York, is admirable. One circular is for young men, another is for young women, and a third is for those having venereal disease.

"Some of the facts all young men should know are: that the true purpose of the sexual function is reproduction and not sensual pleasure; that the testicles have a twofold function, (*a*) reproduction and (*b*) to supply force and energy to other organs of the body; that occasional seminal emissions at night are evidences of normal physiological activity; that sexual intercourse is not essential to the preservation of virility; that chastity is compatible with health; and that the sex instinct in man may be controlled." (Rosenau.)

The prevalence of the venereal diseases in civil life, as shown by the first draft for the National Army in the recent war, came as a distinct shock to many who had believed that the rates for these diseases published by the army and navy in past years indicated a condition of disease and immorality which did not concern the public except as missionaries might be sent among the soldiers and sailors to aid in their reformation. The demonstrated fact that venereal diseases are more prevalent in civil life than in the military and naval services is a sad commentary on the morals of a certain element who have been only too prone to criticize the habits and shortcomings of the commissioned and enlisted personnel of the regular army and navy. However, this illuminating revelation has brought a wholesome reaction. The public is being roused to participation in the campaign for combating the venereal diseases to an extent not anticipated by even the most optimistic leaders of the social hygiene movement before the declaration of war.

2. Provision for accurate and early diagnosis, and treatment in hospitals and dispensaries of infected persons with consideration for privacy of record and provision for following cases until cured.

3. Repression of prostitution by use of police power and control of use of living premises.

4. Restriction of sale of alcoholic beverages.

5. Restriction of advertising of services or medicines for the treatment of sex diseases, etc.

6. Elimination of common towels and toilet articles from public places.

7. Use of prophylactic silver solution in the eyes of the new born.

8. Exclusion of persons in the communicable stages of the diseases from participation in the preparing and serving of food.

9. Personal prophylaxis should be advised to those who expose themselves to opportunity for infection.

THE INFECTED INDIVIDUAL AND HIS ENVIRONMENT. 1. *Recognition of the Disease.* Clinical symptoms, confirmed by bacteriological examination or serum reaction.

2. *Isolation.* For gonorrhea, when the lesions are in the genito-urinary tract, exclusion from sexual contact, and when the lesions are conjunctival, exclusion from school or contact with children, as long as the discharges contain the infecting organism. For syphilis, exclusion from sexual contact and from preparation or serving of food during the early and active period of the disease; otherwise none, unless the patient is unwilling to heed, or is incapable of observing, the precautions required by the medical adviser. For chancroid, exclusion from sexual contact until lesion is completely healed.

3. *Immunization.* None.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* Discharges from lesions and articles soiled therewith. Infected persons must be carefully instructed as to washing and disinfecting the hands after touching the affected parts. Those having gonorrhea must be cautioned regarding the great danger of infecting the eyes with polluted hands.

6. *Terminal Disinfection.* None.

7. *Medical Prophylaxis.* This is not only possible, but efficient. Its application, however, requires time, intelligence, and sobriety in order to be effective. It should be applied within an hour of intercourse. The chances of success decrease rapidly with the lengthening of the time between intercourse and treatment. The treatment is as follows: The entire penis is scrubbed with warm soapy water for several minutes and then washed well with a solution of bichloride of mercury 1-2000 in strength. If there are any abrasions present it is well to spray them with hydrogen peroxide from a hand atomizer. The urethra is then injected with two injections of 10 per cent solution of argyrol or 2 per cent solution of protargol. Each injection should be retained in the urethra for five minutes. After taking the injections, the entire penis is thoroughly anointed with a 33 per cent calomel ointment with lanoline as the base. The man should not urinate for at least two hours, and the ointment should be allowed to remain on the penis for some hours. A temporary dressing may be placed on the parts to protect the clothing.

The above treatment requires dispensary or office facilities when given or supervised by another person. For individual use packets are made up containing bichloride tablets, vials of the silver salts solution and a syringe for urethral injection, and a collapsible tube or small ointment pot of calomel ointment. In the hands of an intelligent and sober man the use of the contents of this packet, immediately after intercourse, is almost certain protection from infection.

Medical Inspector R. A. Bachman, U.S.N., advocates the use of the calomel ointment with the addition of 2 per cent tricresol as the sole protection. It is supplied in collapsible tubes and is injected into the urethra and smeared on the penis immediately after exposure. The results of his laboratory work and the statistics from the practical application of this tube certainly demonstrate a high degree of efficiency.

Prevention of Ophthalmia Neonatorum. In about 65 per cent of cases ophthalmia neonatorum is due to gonococcus infection. Other organisms that sometimes cause conjunctivitis shortly after birth are: streptococci, the meningococcus, the Koch-Weeks bacillus, the pneumococcus, the diphtheria bacillus and staphylococci. These are relatively rare infections. The diagnosis of gonorrheal ophthalmia may be readily made by staining a smear of the secretion.

The disease is caused by the entrance of the vaginal secretion containing gonococci into the conjunctival sac of the child during its passage through the genital tract of the mother. The infection usually occurs just before delivery. The newborn child may be infected after birth by contaminated hands, towels, sponges, or other objects.

The following paragraphs bearing on this exceedingly important subject are quoted from a recent work, "The Blind," by Harry Best, Ph.D.:

"The prevention of blindness from ophthalmia neonatorum is not inherently difficult, involving as it does only taking of very simply but very necessary measures. It can be accomplished with little trouble, and the work if rightly performed is almost certain to be effective. The all-important consideration is the injection into the eyes of the infant shortly after birth, of a very weak solution of silver nitrate or of certain other derivatives of the silver salts, with perhaps also a washing out with a neutral salt solution. Should the eyes of the child be healthy, no harm is done; should, however, they be infected, the disease germs are at once killed. This method, the efficacy of which is now generally recognized, is sometimes called the Credé method, from the name of the discoverer, Professor Carl Credé, who first made application of it in a hospital in Leipzig, Germany, in 1881.

"The method, then, of checking ophthalmia neonatorum is the administration of a prophylactic at birth, or in any event within a short time after the appearance of the infection. It would seem that, now that the value and importance of the measure have been demonstrated, this would be done as a matter of course; yet until comparatively recently such procedure has been hardly more than occasional, and at present is far from being general even in some enlightened communities. The failure is in good part due to ignorance respecting the disease among the public, and in part to the negligence or want of concern among practitioners. In many sections little or no regard has been paid to the matter, indifference being displayed by both physicians and midwives—though at present in a number of places, as we are to find, the situation is now being changed for the better.

"To remedy this condition, and to insure the general use of a prophylactic, several things are necessary: (1) direct requirement of the use of a prophylactic, or a report of all births a short time thereafter, with a statement as to whether or no a prophylactic has been used; (2) report of all cases of eye trouble occurring within a few weeks after birth, with attention to uncared-for ones by health authorities; (3) the providing of supplies of the prophylactic without charge if called for; and, (4) as an incidental, but very important measure, the proper and sufficient regulation of the practice of midwives, in whose hands occur such a large number of births.

"The best and surest measure, aside from that directing absolutely the use of the prophylactic at birth, and perhaps more efficacious than it, is the one that requires the reporting to the health authorities of all births within one day or two after birth, by the physician or midwife in attendance, or by a member of the family or other person interested, with the inclusion of a statement as to whether a prophylactic has been employed. This will not only make certain that proper attention is given the matter as nothing else will, but it permits the following up of every birth by a regular nurse to see that all goes well.

"The second precaution lies in the requirement of the reporting of every case where there has been in the eyes of an infant in its first days, an affection which might lead to blindness. Even though no prophylactic has been used at the time of birth, there yet may be hope of saving the eyes of an infected child if there is immediate report of the appearance, within two or three weeks after birth, of either redness, inflammation, or discharge in the eye, and prompt action is then taken. Such condition is likely to denote the presence of infection, while skilled treatment will in any event insure the preservation of sight. The report should be made not later than six hours after the notice of the trouble, and by the physician, midwife, or other person who has reason to suspect the existence of the disease. The duty of attending upon all otherwise uncared for cases should be imposed upon the local health authorities. Nurses should also be employed for the careful following up of cases, and hospital facilities should be afforded for serious ones.

"Next, in order that there may be no excuse for failure to employ a prophylactic, the preparation should be provided free for all who will use it. An amount sufficient to be dropped into one eye may be placed in a small ampoule, to be dispensed by the local or State authorities. The total cost will be little, a few thousand dollars answering for any one State each year.

"In addition to the foregoing direct measures, special attention will have to be paid to the practice of midwives. It is they whose services are availed of to such a great extent among the poor in large cities, and also in not a few rural districts. In certain foreign quarters of cities their services are almost exclusively demanded. The danger from midwives lies in the circumstance that many are illiterate and unclean, and little likely to take the necessary precautions to prevent blindness. About them will have to be put certain safeguards for the protection of the child. Attendance upon obstetrical cases should not be allowed until there has first been secured a license, which should be given only after suitable examination, and preferably also after a certain training, and which should be revocable for cause. There should be established full regulations for their practice, including periodic inspection, and the prescription of the outfit to be employed.''

''The foregoing constitute the main and most necessary steps to prevent the occurrence of blindness from ophthalmia neonatorum. There are, at the same time, several other measures that may well be invoked to attain this end. Circulars and other printed matter concerning the disease and the means to be employed to avoid it should be prepared and given a wide circulation, especially among mothers, supplemented by lectures and other forms of popular education. To make sure of the acquaintance of physicians with the provisions of the law or with public health regulations, it is advisable that copies of them be included with birth certificates. In the keeping, moreover, of proper records in hospitals, and in the periodic reports of physicians, midwives, and nurses, no little may be accomplished in the detection of the trouble and in the affording of timely treatment.''

The prophylactic treatment of the eyes of the newborn consists in dropping into each eye of the infant immediately after labor one or two drops of a 1 per cent nitrate of silver solution. The solution should be placed between the outer ends of the lids, which should be separated and elevated away from the eyeball so that a pool of the silver solution will lie for one-half minute or longer between them, bathing the entire conjunctiva. It may be neutralized after installation with salt solution. One application is sufficient, further attention is liable to cause a condition known as "silver catarrh." This is the essential part of the treatment, but it is well that the eyelids should receive a preparatory cleansing with sterile absorbent cotton and a saturated solution of boracic acid. A separate pledget should be used for each eye and the lids washed from the nose outward until quite free from mucus, blood, or meconium. Pregnant women should be instructed to bathe the external genitals daily with soap and water and a *clean* wash-rag. In case of a profuse white discharge or any irritating discharge, medical advice should be sought.

In place of the silver nitrate solution argyrol (25 per cent) or protargol (5 per cent) may be used.

Military. A committee of the American Social Hygiene Association has drawn up and submitted to the War Department a program of attack on venereal diseases. This plan has in large measure been put into effect and sufficient time has elapsed to prove that its application is practical in all its essentials and that the public is ready to support the complete program as rapidly as the details of its application to each community involved can be explained to the civil authorities and to the people. Its success is shown by the marked decrease in the number of admissions to the sick reports of the Regular Army, the National Guard and the National Army for venereal diseases contracted after entry into the service. The following is an outline of activities and coöperating agencies embodied in the program of the committee:

Methods of attack upon venereal diseases divide themselves into four classes:

A. Social measures to diminish sexual temptations.

B. Education of soldiers and civilians in regard to venereal diseases.

C. Prophylactic measures against venereal diseases.

D. Medical care.

Social Measures to Diminish Sexual Temptations. (1) The repression of prostitution and the liquor traffic. (2) Provision of proper social surroundings and recreation.

These activities which have to do with social matters largely fall outside the jurisdiction of the medical service of the army, but this service can render these activities more efficient by stimulating and supporting them, wherever such support should be given.

(1) *Repression of Prostitution and Liquor Traffic in Zones around Camps and Cantonments.* Keep careful track of conditions as regards these two matters in surrounding districts, in cities and towns where soldiers go, and in travel gateways.

In camps and zones, we have the following agencies which may be utilized:

The constituted authorities, military and civil.

The Commission on Training Camp Activities, War Department.

Local and national volunteer agencies may be utilized to discover failures and abuses, and to help otherwise in the work under direction of the proper authorities.

Outside the zones a large number of forces can be used. Among these are: state Councils of Defense, civil police and health administrations, associations of commerce, women's clubs, the press, social hygiene and vigilance societies, and other social and religious organizations of influence in civil communities.

(2) *Provision of Proper Social Surroundings and Recreation.* In camps and zones, plan to:

Develop social activities and amusements.

Provide places where soldiers may go for comradeship, to meet friends, to "loaf."

Supply an attractive place, or places, for soldiers to meet their women callers in camps and near camps.

Establish, under police authority, women patrols in zones.

Enforce rules against women being received in soldiers' tents or being allowed the freedom of camps.

Encourage facilities for interesting the soldier in reading, lectures, music, congenial friendships, hobbies.

For this purpose we had for use in camps or zones or both during the recent war: The Commission on Training Camp Activities supervising activities of the Young Men's Christian Association, Young Men's Hebrew Association, Playground and Recreation Association, Knights of Columbus, Young Women's Christian Association through its hostess houses, the American Social Hygiene Association, and other national and local organizations invited to carry on special activities.

Similar provisions for social diversions and proper social surroundings should be provided outside the zones, and if possible, provision at least for their inspection by military inspectors should be provided.

For use outside the zones, we have practically all the above agencies, which are organized to conduct similar work in communities accessible to soldiers but not within the military zones.

An effort should be made to stimulate local organizations in towns near camps and at railroad centers to furnish proper social diversions and amusements for soldiers, and to provide places where they may go when on leave.

Enlisted men's clubs for this purpose, charging a small monthly membership fee, say twenty-five cents, are greatly to be desired.

Organizations of men and mature women to furnish members to meet soldiers in a friendly way, and to give them information and directions are desirable in towns and at railroad centers and other points where soldiers come in numbers. Fraternal organizations should be enlisted in this work.

Pressure should be brought to bear on the civil authorities to suppress vicious amusement places, to clean up parks and other recreation places, and to furnish morals police for such places. For this purpose, the members of special law enforcement organizations could be used.

Inspection of social and moral conditions in the camps, in the zones, and in contiguous districts and of the work being done by the various agencies for social betterment should be made by federal authorities. Similar volunteer inspections by dependable vigilance and other civic associations should be encouraged.

Education of Soldiers and Civilians. (1) *For soldiers*: (*a*) Lectures; (*b*) Pamphlets; (*c*) Exhibits.

(*a*) Lectures to soldiers should be given by medical and line officers and by competent volunteers furnished by outside agencies under invitation and direction of the Medical Department. These, beside inculcating continence, should explain the risk and waste of venereal diseases and the program adopted to avoid them. Lectures without authority should not be permitted.

(*b*) A pamphlet should be given the soldier as soon as possible after enlistment. This pamphlet should be very brief and should warn the soldier of the venereal dangers to which he may be exposed and give him instructions, if he should be exposed, to report as promptly as possible to his regimental infirmary.

It would be very desirable if a pamphlet could be distributed at the places of meeting of the Exemption Boards. Later somewhat fuller pamphlets should be distributed to soldiers through medical and line officers, or by accredited volunteer social hygiene societies.

(*c*) Exhibits and other demonstration methods should be adapted to the needs of military life and furnished to each cantonment.

(1) *For civilians.* In the attack upon the venereal problem it is highly desirable that such educational activities as those outlined above should be organized for the civilian population.

The influence of the military authorities should be given to the national organizations for social hygiene and to the numerous sanely conducted local organizations of the same sort.

Encouragement should be given to the organizations which are undertaking to arouse the interest of the women population of the country in matters of social hygiene and for instructing women in regard to venereal diseases.

Organizations dealing with these matters which attempt to reach women should be encouraged, especially in the vicinity of camps. An increasing number of influential organizations such as the General Federation of Women's Clubs and Patriotic Women's League, are indorsing and supporting sound social hygiene programs, and supplementing the more specialized efforts of such organizations as the Young Women's Christian Association and the Women's Christian Temperance Union.

PROPHYLACTIC MEASURES. *Instruction in Prophylaxis.* Soldiers should be informed of the fact that there are prophylactic measures that reduce the dangers of venereal infection. But this instruction should take particular care to inform them that there are limitations to such prophylactic measures, and that they furnish only partial protection and in no sense give freedom from risk. It should be most carefully impressed upon them that the longer the interval between exposure and preventive treatment the greater the danger of infection. It should be made clear to them that if they do expose themselves but do not take the preventive treatment and develop a venereal infection, they are subject to trial by court martial and in addition lose all pay during the time they are on the sick report as a result of their indiscretion.

Regimental Infirmaries. The provision of prophylaxis (early treatment) in regimental infirmaries, which should be open day and night, is imperative in any sane attack upon venereal diseases. The prophylactic station should be utilized as a place for personal advice and education against future exposure, and should be conducted as an early-treatment dispensary.

Infirmaries in Civil Centers. In cities, where there are no adequate civil dispensaries to be used and through which soldiers in considerable numbers pass, either while on leave or in travel, there regimental infirmaries should be provided in accessible locations. In a few cities, where dispensary services are particularly well developed, regimental infirmaries may be replaced to advantage by accrediting these civil dispensaries for use. Information should be furnished to soldiers of the existence and location of such infirmaries and available dispensaries.

Leaves of Absence. In the interest of health, long leaves of absence for soldiers should as far as possible be discouraged. Leaves of absence of more than twenty-four hours are particularly dangerous, and it would be advantageous if leaves of absence were timed from as early an hour in the day as possible.

In cases where soldiers have been exposed, particularly if for any reason exposure seems unusually dangerous, special observation should be made, and if practicable these observations should be repeated at intervals of a couple of days for two or three weeks.

All pressure possible should be made by military authorities against houses or women which experience shows are frequent sources of infection, and this should be extended as far as practicable to prostitution generally. The more effective the repression of prostitution can be made the greater will be the reduction in venereal diseases. All possible influences should be brought to bear to encourage civil authorities in the attack upon prostitution in all its phases.

A medical program for civil communities equivalent to the military program for prevention and treatment should be encouraged.

Medical Care. *Hospital Organization.* There should be a special service in each cantonment hospital to care for skin and venereal diseases.

As far as possible, all such cases should be in charge of the venereal service, and where for any special reasons, such cases must be under other services, the senior officer of the venereal services should be, if possible, consulted in regard to them. In the venereal disease service, there should be at the head an experienced specialist in these diseases, and whenever possible, another medical officer trained in venereal diseases should also be in the service. The other medical officers assigned to the service need not necessarily at the beginning be trained in venereal diseases.

Hospital Cases. The cantonment hospitals should have under their care all cases of venereal diseases which are in the acute, infectious stages. These include:

All cases of acute gonorrhea.

All cases of syphilis during the early infectious stage and which have chancres, mucous patches, or condylomata.

Care should be taken that hospitalization of venereal disease does not become an abuse which is allowed to interfere unduly with military duty.

There should be no leaves of absence for infectious venereal cases, and cases which have passed the acute infectious stage, but which might become dangerous through the possible development of mucous patches or of chronic gonorrheal discharge, should not be allowed leaves of absence from camp.

War Department Orders and Directions Regarding Venereal Prophylaxis:

G. O. No. 17, W. D., Washington, May 31, 1912.

1. It is enjoined upon all officers serving with troops to do their utmost to encourage healthful exercises and physical recreation and to supply opportunities for cleanly social and interesting mental occupations for the men under their command; to take advantage of favorable opportunities to point out, particularly to the younger men, the inevitable misery and disaster which follow upon intemperance and

moral uncleanliness, and that venereal disease, which is almost sure to follow licentious living, is never a trivial affair. Although the chief obligation and responsibility for the instruction of soldiers in these matters rests upon company officers, the medical officers should coöperate by occasional lectures or other instruction upon the subject of sexual physiology and hygiene and the dangers of venereal infection.

2. Commanding officers will require that men who expose themselves to the danger of contracting venereal disease shall at once upon their return to camp or garrison report to the hospital or dispensary for the application of such cleansing and prophylaxis as may be prescribed by the Surgeon-General. Any soldier who fails to comply with such instructions, if found to be suffering from a venereal affection, shall be brought to trial by court-martial for neglect of duty.

3. Commanding officers will require a medical officer, accompanied by the company or detachment commander, to make a thorough physical inspection twice in each month of all the enlisted men (except married men of good character) of each organization belonging to or attached to the command. These inspections will be made at times not known beforehand to the men and preferably immediately after a formation. The dates on which the physical inspections of the various organizations are made will be noted on the monthly sanitary reports.

At these inspections a careful examination of the feet and footwear and the condition of personal cleanliness of the men will be made, as well as careful observation for the detection of venereal diseases.

Cases of the latter will be promptly subjected to treatment, but not necessarily excused from duty unless, in the opinion of the surgeon, deemed desirable. They will be made of record in the medical reports in any case. A list of those diseased but doing duty will be kept by the company or detachment commander and the surgeon, and the infected men will be required to report to a medical officer for systematic treatment until cured. While in the infectious stages the men should be confined strictly to the limits of the post. When a venereal case, whether or not on a sick report, is transferred to another command, the surgeon will send a transfer slip giving a brief history of the case.

4. All instructions from the War Department prohibiting the publication in printed or other orders of instructions prescribing examinations having in view the detection of venereal diseases among enlisted men, heretofore issued, are recalled.

By order of the Secretary of War: LEONARD WOOD,
Major General, Chief of Staff.

Official:
W. P. HALL,
Adjutant-General.

Confidential Circular to Medical Officers: W. D., Office of the Surgeon General, Washington, June, 1912.

The following directions for carrying out the system of venereal prophylaxis directed by par. 2, G. O. 17, W. D., 1912, are published for the information and guidance of medical officers:

A suitable, easily accessible room in the hospital (or dispensary) at each post will be selected for this purpose, which should be provided with a good light and such medical supplies, basins, and other equipment as may be necessary. A competent, properly instructed man of the Hospital Corps, or more when necessary, will be on duty there between retreat and réveille, and will be within call at all other hours.

The procedure in the case of men reporting for treatment will be as follows:

1. The name, rank, and organization of the soldier, with the day and hour of treatment should be entered for record on a card furnished for the purpose, which will afterward be examined and authenticated by the initials of a medical officer. These records should be regarded as confidential, and should be kept in a secure place and not shown to unauthorized persons or except upon proper authority. They will not be preserved longer than three months.

2. The genital organs will be thoroughly washed with soap and warm water.

3. An injection will be made into the urethra of 4 c. c. of the standard solution of 2 per cent protargol dissolved in glycerine 15 parts, water 85 parts. This should be retained in the urethra for three minutes. In individual cases when the protargol solution is found to produce an irritating effect, a 20 per cent solution of argyrol may be used. Other solutions or modifications of these solutions will not be used for routine administration.

4. The entire penis will be rubbed with calomel ointment (30 per cent in benzoated lard), care being taken that the folds of the prepuce and about the frenum are thoroughly covered. If any pimples or abrasions exist about the scrotum or the public region, these should also receive an application of the ointment.

The parts should be then wrapped in a napkin of soft paper furnished for the purpose, in order to protect the clothing.

A record of each prophylactic treatment should be kept on the Venereal Prophylaxis card, form 77, M. M. D.

Naval. The sailor ashore lives under the same conditions and is subject to the same temptations as the soldier. The methods of attack upon venereal diseases embodied in the program submitted by the committee of the American Social Hygiene Association and now in successful operation have benefited the Navy as well as the Army.

The medical prophylactic treatment in use in the Navy is that described under "Medical Prophylaxis." For ethical reasons the prophylactic packet is no longer supplied to the men nor sold in the canteens or post exchanges.

The following letter gives the present status of venereal prophylaxis in the Navy:

DEPARTMENT OF THE NAVY

BUREAU OF MEDICINE AND SURGERY

WASHINGTON, D. C.
December 5, 1917.

To All Medical Officers, via Official Channels.

SUBJECT: Medical measures relative to the prevention and control of venereal diseases.

1. This letter is written by direction of the Secretary of the Navy.

2. Information has reached the Bureau from various sources tending to indicate that some medical officers are yet in doubt as to their duties and proper activities in regard to medical measures for the control and prevention of venereal diseases, particularly in respect to compulsory early treatment and medical prophylaxis in the case of men returning from liberty or leave of absence who have exposed themselves to infection, and in respect to medical examinations for the detection of concealed disease.

3. "Every medical officer shall lay emphasis upon the evil of incontinence and the sin of it, as well point out the dangers of contracting immoral and disgusting diseases which destroy physical as well as moral manhood. Most men who come into the Navy are young and inexperienced, and therefore to be warned of the dangers to which they are exposed. Medical officers are charged with this duty, the highest duty as to prevention which they can perform. Ability to fight is dependent upon sound bodies. The yielding to temptation which brings disease is at all times to be guarded against, but in time of war it becomes a matter of serious military consequence."

4. In addition to thorough education of all the men as to the nature

and dangers of venereal infections, the issue of approved "warning circulars," constant endeavor to appeal to the best in the nature of all men, and inculcation of high moral standards, medical officers will use their best efforts for the prompt detection of venereal diseases and for the enforcement of early and thorough treatment.

5. To this end, wherever there are medical department facilities, hospitals, dispensaries, camp dispensaries, or sick bays, provision shall be made for the examination and treatment of men ill with venereal diseases and men who have been exposed to venereal infections.

6. Art. 2955, Navy Regulations, provides that whenever, in the opinion of the Senior Medical Officer, any members of the crew have concealed diseases, he shall, with the approval of the Commanding Officer, examine them and place any that seem to require it under appropriate treatment; such examinations shall also be made when directed by the Commanding Officer. This duty may be delegated to junior medical officers only. This article is in section 3, relative to the duties of the medical officer of a ship, but it has been changed to make it apply with equal force to medical officers of shore stations, naval training stations, training camps, schools, and section bases, or wherever there are enlisted personnel of the regular Navy, naval reserve forces, or national naval volunteers, or anybody in the naval service.

7. All men returning to their ships or stations shall be given an opportunity to admit exposure to infection with venereal disease if such exposure shall have occurred, and all such men shall receive early prophylactic treatment and continued treatment until cured if prophylaxis fails.

8. Men who have violated the admonitions of the medical advisers and have exposed themselves to infection, and who do not avail themselves of the opportunity to receive early prophylactic treatment at their stations or on board their ships, shall be regarded as having concealed venereal disease, if such disease develops, and such men shall be reported to the Commanding Officer as having concealed venereal disease.

9. Men under treatment for venereal diseases shall not be recommended for liberty except in case of most urgent business or imperative personal necessities. This shall apply in all cases where the stage of the disease is such that infection may be transferred by sexual as well as ordinary contact. Men harboring infection shall be kept out of civil communities at home and abroad.

10. Full coöperation with the agents of the Commission on Training Camp Activities is desired, and any evidence that may be obtained from men who have become infected, as to the source of infection, should

be given to the agents of the commission who have to do with enforcement of existing laws relative to the disposition of female carriers in the civil community.

W. C. Braisted.

The States are now rapidly adopting regulations which make the venereal diseases notifiable and place them on the same footing as other communicable diseases. Many of the States have adopted regulations modeled after suggestions approved by the Surgeons General of the Army, Navy, and the Public Health Service. Some of them have made definite arrangements to coöperate with the Federal Government by having an officer of the Public Health Service assume charge of venereal disease control, under the joint supervision of the State health department and the United States Public Health Service. In practically all of these States regulations have been passed which provide ample legal authority for dealing with the problem according to the plan approved by the Surgeons General of the Army, Navy, and the United States Public Health Service. Consequently the work of the medical officer in charge of venereal disease control is largely directed toward the organization of the State to carry out the program already agreed upon. This organization is being developed along four principal lines, as follows:

(1) Educational: Acquainting the public with the nature of the diseases and the objects desired to be accomplished.

(2) Law enforcement: Securing coöperation of the physicians in reporting cases, and of the police in apprehending prostitutes, vagrants, and such other persons as can be reasonably suspected of having venereal disease in communicable stages.

(3) Propaganda to secure local funds for providing detention homes and hospital facilities for isolation and treatment of venereal disease carriers who by their habits are a menace to the public health.

(4) Establishment of increased facilities for early diagnosis

and treatment. The Wassermann test should be performed free of charge in State and local public health laboratories; salvarsan should be provided by State health departments; free dispensaries should be maintained by local health departments for venereal diseases as is done for tuberculosis and child welfare work.

The following regulations were promulgated by the Secretary of the Treasury, under which state boards of state departments of health receive the allotment of funds provided in Section 6, Chapter XV, of the Act approved July 9, entitled "An Act making appropriations for the support of the army for the fiscal year ending June 30, 1919."[1]

[1] Reprint from the Public Health Reports, vol. 33, No. 37, Sept. 13, 1918, pp. 1537-1540.

The act provides that $1,000,000 shall be distributed to the States for the use of their respective boards or departments of health in the prevention, control, and treatment of venereal diseases, this sum to be allotted to each State, in accordance with rules and regulations prescribed by the Secretary of the Treasury, in the proportion which its population bears to the population of the continental United States, exclusive of Alaska and the Canal Zone, according to the last preceding United States census.

State boards or departments of health receiving their respective allotments shall agree to the following coöperative measures under which their appropriation shall be expended:

1. Put into operation through a legislative enactment or a State board of health regulation having the effect of law, regulations in conformity with the suggestions approved by the Surgeons General of the Army, Navy, and United States Public Health Service, for the prevention of venereal diseases. The minimum requirements of these rules are:

(*a*) Venereal diseases must be reported to the local health authorities in accordance with State regulations approved by the United States Public Health Service.

(*b*) Penalty to be imposed upon physicians or others required to report venereal infections for failure to do so.

(*c*) Cases to be investigated, so far as practicable, to discover and control sources of infection.

(*d*) The spread of venereal diseases should be declared unlawful.

(*e*) Provision to be made for control of infected persons that do not coöperate in protecting others from infection.

(*f*) The travel of venereally infected persons within the State to be controlled by State boards of health by definite regulations that will conform in general to the interstate regulations to be established.

(*g*) Patients to be given a printed circular of instructions informing them of the necessity of measures to prevent the spread of infection and of the importance of continuing treatment.

2. An officer of the Public Health Service shall be assigned to each State receiving allotments for the general purpose of coöperating with the State health officer in supervising the venereal-control work in the State. This officer to be selected by the State health authorities and to be approved and recommended for appointment by the Surgeon General of the Public Health Service. The salary of this officer will be paid by the State out of the funds made available from the allotment, except a nominal sum of $10 per month, which will be paid by the United States Public Health Service. In those States where a bureau of venereal diseases has already been established, with a full-time medical officer in charge, the present incumbent may be recommended for appointment by the State health officer, and, with the approval of the Surgeon General, United States Public Health Service, he will be appointed as an officer of the Public Health Service. The general plan of work for the State bureau of venereal diseases will be:

(*a*) Securing reports of venereal infections from physicians and others required to report, in accordance with State laws.

(*b*) Suppressive measures, including the isolation and treatment in detention hospitals of infected persons who are unable or unwilling to take measures to prevent themselves becoming a menace to others, the establishment of free clinics for the treatment of venereal diseases, and the elimination of conditions favorable to the spread of venereal infections.

(*c*) Extension of facilities for early diagnosis and treatment through laboratory facilities for exact diagnosis and scientific determination of condition before release as non-infectious, in accordance with the standardized procedure that will be prescribed by the United States Public Health Service.

(*d*) Educational measures to include informing the general public, as well as infected individuals, in regard to the nature and manner of spread of venereal diseases and the measures that should be taken to combat them.

(*e*) Coöperation with local civil authorities in their efforts to suppress public and clandestine prostitution. The clinics referred to under (*b*) will form centers from which the other measures may be conducted by discovering the presence of infections, the securing of data for enforcing the regulations for reporting these diseases, and the institution of educational measures appropriate to particular communities. The immediate reduction in venereal-disease foci resulting from clinic treatment will result in a marked decrease in the prevalence of such diseases in both the military and civil population.

(*f*) Accurate detailed records must be kept of all the activities of the venereal-disease work. These will include careful records of each case treated, amount of arsphenamine used, final results, and disposition made of patients. Copies of these records must be forwarded to the Surgeon General, United States Public Health Service, as a report at such intervals as they may be requested, and in accordance with instructions regarding the form of report.

3. Local funds that may be available, or that may become available from legislative appropriations or any other source for venereal-disease control, shall be used by the State or city health authorities having jurisdiction for the extension of the work, and such local funds must not be conserved through the expenditure of the funds that are allotted by the Congress through the United States Public Health Service.

4. In extension of the educational measures the State's health authorities and its bureau of venereal diseases shall exert their efforts and influence for the organization of a State venereal-disease committee that will be unofficial in character, but a valuable coöperative agency for furthering the comprehensive plan for Nation-wide venereal-disease control.

5. The State health authorities shall take such measures as may be found practicable and decided upon in conference between the Public Health Service and State board of health representatives for the purpose of securing such additional legislation as may be required for the development of control of the spread of venereal infections. Action shall be taken to limit or suppress the activities of advertising "specialists" and quacks by prosecuting them under State laws, or such other measures as may be applicable and effective.

6. In expending the sum allotted a State, the rules and regulations to be promulgated by the interdepartmental social hygiene board for the expenditure of the $1,000,000 civilian quarantine and isolation fund under control of the Secretary of War and Secretary of the Navy shall be given consideration by Public Health Service and State board of health representatives, so that the military necessities of each particular State may receive the consideration due its relative importance, and so that funds from the two sources may be correlated.

7. The State allotment shall be expended along general standard lines for all States and in accordance with an accounting system, to be forwarded by the interdepartmental social hygiene board, approximately as follows:

(*a*) For treatment of infected persons in hospitals, clinics, and other institutions, including arsphenamine and other drugs, 50 per cent of the allotment.

(*b*) In carrying out educational measures, 20 per cent.

(*c*) In carrying out repressive measures, 20 per cent.

(*d*) In general administration and other activities of venereal disease control work, 10 per cent.

(This distribution is provisional and subject to modification after conference and agreement between each State and the United States Public Health Service to best meet the needs of the particular State.)

8. In carrying out the general Government program the administrative organization of the United States Public Health Service will be available at all times to State organizations in coöperative work, and assistance will be given to States whenever possible through the detail of employees, the securing of arsphenamine, providing literature for the educational measures and in such other ways as may be found practicable as the work develops.

W. G. McAdoo,
Secretary of the Treasury.

Washington, D. C., *September 4, 1918.*

The following memorandum was issued from the Surgeon General of the U. S. Public Health Service relative to the control of the venereal diseases:

1. Epidemiology.
   - (*a*) Peculiar to the human species.
   - (*b*) Chronic diseases.
   - (*c*) Spread by contact—not necessarily sex contact—chronic carriers.
   - (*d*) Very prevalent in all classes of society.
   - (*e*) Most prevalent in classes of low inhibition.
2. Control.
   - (*a*) Depends upon the control of infected persons.
   - (*b*) Control of infected persons depends upon knowledge of their whereabouts. This may be determined by:
     - (1) Morbidity reports by serial number (in the case of private practitioners), name to be disclosed when

2. Control—*Continued.*

infectious persons cease treatment. Case then followed up by health department which enforces quarantine act.

(2) Morbidity reports from venereal clinic and hospital.

(3) Legal enactment necessary to secure morbidity reports.

(4) Enact and enforce ordinance requiring pharmacists to keep record (open at all times to health department) of sales of drugs for the prevention and treatment of gonorrhea and syphilis.

(*c*) Object of this control is to prevent contact between infected and non-infected persons.

(*d*) May be obtained by:

(1) Quarantine of infected persons.

(2) Cure of infected persons.

(3) Education of general public to avoid direct and indirect contact with persons infected or presumably infected.

3. Quarantine of infected persons.

(*a*) Those who desire cure and can afford treatment.

(1) These are instructed by their physicians and theoretically are thus quarantined.

(*b*) Those who desire cure and can not afford treatment.

(1) Means should be provided for the free treatment of this group.

(*a*) Accurate diagnosis.

(*b*) Dispensary relief.

(*c*) Hospital relief.

(*c*) Those who are careless or willful in the distribution of these infections through promiscuity.

(1) These for the most part are the ignorant or the criminal classes. Careful physical examination of all persons entering jails or other public institutions, those found infected to be isolated either in a special hospital or under a probation officer who enforces dispensary relief.

4. Cure of infected persons.

(*a*) Establishment of venereal clinics by health authorities.

(1) Federal, in zones in close contiguity to cantonments.

(2) State, in situations where local authorities refuse or fail to establish clinic.

4. Cure of infected persons—*Continued.*
    (3) City, particularly those cities in which commercialized or clandestine prostitution flourishes for the patronage of soldiers but is beyond the authority of the Secretary of War.
    (4) Country, in thickly settled rural communities.
  (*b*) By the creation of new or the utilization of existing hospital facilities.
    (1) For the treatment of those who volunteer for treatment.
    (2) For the obligatory treatment of persons under control of the courts.
  (*c*) By legal enactment.
    (1) Declaring the venereal infections to be quarantinable.
    (2) By substituting confinement to hospital for confinement to jail in the case of those convicted by courts and having venereal infections.
    (3) By substituting remanding to a probation officer for the imposition of fines.
    (4) To carry out 2 and 3 it is necessary that all persons arrested be examined by the city physician or other authorized person.
    (5) By arrest of acknowledged and clandestine prostitutes by police-women.

5. Public education.
  (*a*) Relieve problem of all moral and social issues and place campaign solely on basis of control of communicable disease.
  (*b*) Propaganda of wisely conducted publicity.
    (1) Through public meetings addressed by forceful speakers.
    (2) Through public prints.
    (3) By placarding public toilets, placards to emphasize danger of venereal diseases and to recommend prompt treatment either by competent physician or at the free venereal clinic.
    (4) By follow-up work by social workers.
    (5) By the education of infected persons.
      (*a*) By physicians in private practice.
      (*b*) By venereal clinic and hospital.

Chapter IV

THE INSECT-BORNE DISEASES

Mosquitoes

Malaria

Synonyms. Chills and fever, fever and ague, swamp fever.

Definition. An infectious disease characterized by: (*a*) paroxysms of intermittent fever of quotidian, tertian, or quartan type; (*b*) a continued fever with marked remissions; (*c*) certain pernicious, rapidly fatal forms; and (*d*) a chronic cachexia, with anemia and enlarged spleen.

Geographical Distribution. In the temperate zones the foci of epidemics are becoming more restricted every year. In Europe it is chiefly seen in Southern Russia, the Balkans, and certain parts of Italy. There are many districts in the Southern States in which the disease still prevails. It is very prevalent in many parts of the tropics, especially India, the Gold Coast of Africa, and the Atlantic coast lines of Central America.

Predisposing Conditions. A warm season or climate, and the presence and opportunity for breeding of certain species of different genera of the Anophelinæ family of mosquitoes are the chief predisposing factors.

Infectious Agent. Three species of protozoan parasites belonging to the Family Plasmodidæ, *Plasmodium malariæ, Plasmodium vivax,* and *Plasmodium falciparum.*

Source of Infection. The blood of an infected individual.

Dissemination. By bite of the infected Anopheles mosquitoes. The mosquito is infected by biting an individual suffering from acute or chronic malaria. The parasite develops in the body of the mosquito for from ten to fourteen days, after which time the sporozoites appear in its salivary glands.

Portal of Entry. The minute wounds made in the skin by the bites of the mosquitoes.

Incubation Period. Varies with the type of species of infecting organism. Experimental cases gave the following results: Tertian, twelve to fourteen days; quartan, fifteen days; estivo-autumnal, five days.

Period of Communicability. As long as the malaria organisms exist in the blood.

Immunity. Certain individuals are immune to malaria and experimental malaria, and some present this property after a mild fever has been cured by quinine. Some authors state that white people living in malarious districts in time show marked immunity.

Prophylaxis. General Measures. 1. Employment of measures for destroying larvæ of anophelines and the eradication of breeding places of such mosquitoes. Upon limited water surfaces the former is accomplished by a film of coal oil or the Panama larvacide. The most effective way to abolish the breeding places of malaria mosquitoes is to fill up low places or to dry the surface of the land by drainage. The details of these procedures are given in the section on "General Prophylaxis."

2. Blood examination of persons living in infected areas to determine the incidence of infection.

3. Screening sleeping and living quarters; use of mosquito nets.

4. Killing mosquitoes in living quarters.

The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms, always to be confirmed by microscopical examination of the blood. Repeated examinations may be necessary.

2. *Isolation.* Exclusion of patient from approach of mos-

quitoes, until his blood is rendered free from malarial parasites by thorough treatment with quinine.

3. *Immunization.* None. The administration of prophylactic doses of quinine should be insisted upon for those constantly exposed to infection and unable to protect themselves against Anopholes mosquitoes. This does not prevent infection, but only destroys the parasites in the blood during the period of incubation. In Panama good results were obtained by the use of moderate doses, 3 to 6 grains per day. When the disease increases in prevalence the amount should be raised to 8 or 10 grains per day, then dropping off to 4 or 5. The administration of large doses, 16 grains, at intervals of from six to ten days according to the danger of the infection, has been found effective in the very malarious districts of German West Africa and in Formosa.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* None. Destruction of Anopheles mosquitoes in the sick room.

6. *Terminal Disinfection.* None. Destruction of Anopheles mosquitoes in the sick-room. The methods for destroying mosquitoes are described in the section on "Insecticides."

A successful anti-malaria campaign depends upon the suppression of the mosquito and the elimination of the parasite in the human hosts. The former is a difficult and expensive undertaking. It is possible in the laboratory and in small areas, but in extensive areas the difficulties can only be surmounted by governmental means, as on the Isthmus of Panama during the building of the canal. Screening and quinine prophylaxis are only temporary measures; more attention should be paid to the radical cure of those harboring the parasites. The best time to attack the parasites in man is during the winter and early spring, so as to prevent infection of the new summer brood of mosquitoes.

Military. *Methods of Control*: 1. Early notification of all cases of malaria, with laboratory diagnosis giving the type of parasite.

2. If possible a survey of the personnel to detect carriers.

3. Efficient treatment of all cases, following each case with a malarial register. (Form 56, Medical Department, U.S.A.) If treatment is efficient, the disease will not become latent, gametocytes will not be formed, and the case will not become a carrier capable of infecting mosquitoes.

The minimum treatment recommended is:

Quinine grains xxx daily until symptoms are gone and plasmodia cannot be found; then

Quinine, grains xv daily for two weeks; then

Quinine, grains x daily for two weeks; then

Quinine, grains vi daily for at least two months.

Measures to be taken against mosquitoes and their larva and measures to prevent mosquitoes from biting are discussed under "General Prophylaxis" and "Military Sanitation."

Military exigencies permitting, before establishing a post or cantonment in an unknown country, measures should be taken to determine whether malarial fevers are present or not, and, if so, to what extent. This is best done by the examination of the blood of natives and of mosquitoes for the development stages of the plasmodia.

The prophylaxis of a post or camp, in a malarious district, involves likewise that of the surrounding communities; much can be done in that direction by education so as to secure the coöperation of all concerned and develop an appreciation, even by the poor and ignorant, of the advantages of screening, mosquito bars, and quinine. (Havard.) This work is now being done in the zones around the camps and cantonments in the United States by the Public Health Service and the Red Cross.

Naval. The protection of the naval forces ashore requires the application of the same measures described for the military establishment.

Prophylaxis aboard ship is discussed in the section on "Naval Sanitation."

Yellow Fever

Synonyms. Yellow jack, black vomit, bilious remittent fever, typhus icteroides, pestis americana, vomito negro.

Definition. An acute, infectious disease occurring endemically and at times epidemically within a rather limited geographical zone. It is characterized by an abrupt period of invasion, a period of remission, and in turn a second febrile stage and symptoms peculiar to the affection, viz., black vomit, jaundice, and suppression of urine.

Geographical Distribution. The two principal endemic centers are: (1) The coast of the Gulf of Mexico and the West India Islands; (2) a limited portion of the West Coast of Africa, notably Sierra Leone.

America is probably the aboriginal home of yellow fever, as the first reliable accounts of its prevalence in Africa are of a much later date than those of the West Indies. It is probable that the African coast was infected by slavers from the Antilles. From the endemic center in the West Indies and the Central American coast it has, from time to time, extended along the east coast of South America as far as Buenos Ayres and Montevideo. From the time of its introduction into Bahia by ship via New Orleans in 1847 it was endemic in the large cities of Brazil until eradicated by the improved sanitary methods developed by the American Army medical officers in Havana in 1900-1901. From the Isthmus of Panama, where it was endemic until stamped out by General Gorgas during the building of the Panama Canal, it extended along the Pacific Coast as far south as Peru and as far north as the Gulf of California.

In 1911 a few cases appeared in Honolulu, having been introduced from the west coast of South America. This is most portentous, as it demonstrates the possibility of the disease spreading to other islands of the Pacific, the Philippines, the East Indies, and the continent of Asia, all habitats of *Aëdes calopus.*

The principal American epidemics were Philadelphia and New York in 1793, 1797, 1798; the Southern States in 1853, 1867, 1878; Florida in 1888; New Orleans and Pensacola in 1905. In 1906 it failed to reappear on account of the wholesale destruction of *Aëdes calopus* in 1905.

Southern Europe has suffered several severe epidemics, viz., Cadiz, 1800; Barcelona, 1821; Lisbon, 1857. It has many times been introduced into Spain and Portugal without becoming epidemic. It was once introduced into Italy from Spain. It has been introduced three times into British seaport towns, but has never gained a foothold.

Predisposing Conditions. The absolutely essential condition for the development of yellow fever in the epidemic form in a given locality is the presence of the specific infecting mosquito. Without this insect the disease cannot be propagated. *Aëdes calopus* being a domestic mosquito, yellow fever does not readily spread in rural districts. It is an urban disease, even villages being seldom affected.

The virus requires a temperature of 75° F. for its development in epidemic form. It ceases to spread when the temperature falls below that point and is eradicated when the freezing point is reached. Dampness favors its propagation. While the sea coast, flat delta country, and the banks of rivers are principally affected, yellow fever has occurred in cities in the mountain regions of Mexico and Central America. It prevails only in warm weather and, in temperate climates, only in summer. It is completely arrested by one or at most two severe frosts.

Children are more liable to the disease than adults, males more than females, and whites more than blacks. Natives of an endemic area are far less liable than newcomers, probably because of mild or unrecognized attacks in infancy or childhood.

The virus resembles the organisms of malaria in that it exists in the blood, is taken up by a particular species of mosquito, develops in the mosquito during a period of some days, and is transmitted to new subjects only by subsequent bites of the mosquito.

Infectious Agent. Recent work by H. Noguchi at Guayaquil and in Yucatan has demonstrated that the probable cause of yellow fever is *Leptospira icteroides.*

Source of Infection. The blood of infected persons.

Dissemination. Yellow fever is transmitted by the bites of the female of the mosquito (*Aëdes calopus*). It is *not* spread by fomites, water, food, or contact, direct or indirect. It may possibly be spread by other species of Aëdes, as yet undetermined.

It is a place disease. If *Aëdes calopus* is present in a locality it may, and probably would, become an epidemic or endemic center if a yellow fever patient were brought there and not *absolutely* protected from the bites of that particular species. If the insect is not present patients may be brought to a place or visited with impunity. There is no logical reason, except public sentiment, why a yellow fever patient should not be treated in a general hospital.

Many mild and atypical cases occur, chiefly in children, which are impossible to recognize. These cases probably account for the apparent immunity of the inhabitants of yellow fever endemic centers and for the existence of the disease in those places in endemic form.

If *Aëdes calopus* is brought to northern ports during warm weather it propagates. It is probably not perpetuated in cold weather either as egg, larva, or winged insect. It disappears in the fall, and a fresh importation is required with the return of warm weather.

The possibility of infected mosquitoes on board ship is of vital importance. According to Doty it is rare under modern conditions. No case of yellow fever has arrived at New York Quarantine during the past fifteen years that could not be traced to infection at the port of departure. Some of the voyages were of about three weeks' duration, ample time for the virus to have developed in the bodies of the mosquitoes. Mosquitoes imprisoned in cargoes soon perish; those not imprisoned are soon lost at sea. Modern ships, especially steamers, are kept in comparatively good sanitary condition, thus presenting less chance for Aëdes to breed on board. The voyages are also shorter than in the days of sailing ships.

In former times the hot, low-lying, unsanitary districts around the wharves and docks of seaport towns afforded ideal breeding places for *Aëdes calopus.* The infected and non-infected mosquitoes came aboard the filthy sailing ships and with the offensive cargoes and bilge water carrying stegomyia larvæ, were carried to ports not in the yellow fever zones. The cargoes were discharged and the bilge water pumped or thrown out at the wharves. The larvæ developed and transmitted the disease already introduced by the infected mosquitoes. The residential sections of Cuban and other cities in yellow fever countries are not, as formerly, near the water front. Mosquitoes coming aboard ship at these ports are not now so liable to be infected, as Aëdes breed near human habitations.

Portal of Entry. The virus enters the body only through bites in the skin made by the infecting mosquitoes.

Incubation Period. Three to five days, sometimes extending to seven or eight days. This is of great importance in quarantine work. The virus remains in the body of the mosquito twelve days before becoming infectious.

Period of Communicability. First three days of the attack.

Immunity. Permanent immunity generally results from an attack. Two attacks have been recorded.

Prophylaxis. General Measures. Eliminate mosquitoes by rendering breeding impossible.

The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms.

2. *Isolation.* Isolate from mosquitoes in a special hospital ward or thoroughly screened room. If necessary the room or ward should be freed from mosquitoes by fumigation. Isolation necessary only for the first three days of the fever.

3. *Immunization.* None.

4. *Quarantine.* Contacts for six days.

5. *Concurrent Disinfection.* None.

6. *Terminal Disinfection.* None. Upon termination of the case the premises should be rendered free from mosquitoes by fumigation.

Epidemic Measures. 1. Inspection service for those ill of the disease.

2. Fumigation of houses in which cases of disease have occurred, and of all adjacent houses.

3. Destruction of *Aëdes calopus* mosquitoes by fumigation; use of larvacides; eradication of breeding places.

The knowledge that the mosquito is the carrier of yellow fever makes an effective system of prophylaxis possible. The anatomy and habits of the Culicidæ were discussed in the section on "Dissemination of Communicable Diseases," to which reference should be made.

The following factors are necessary to produce an epidemic:

1. The presence of the *Aëdes calopus* mosquito.

2. Cases of the disease from which the mosquito may become infected.

3. Conditions of temperature, moisture, etc., suitable for the development of the virus in the body of the mosquito.

4. Water available for the breeding of *Aëdes calopus.*

5. The presence of non-immune persons for the mosquitoes to infect.

Some of these factors can be controlled by human agencies, others partially so or not at all.

As ships frequently carry the disease as cases and more rarely as infected mosquitoes, maritime quarantine assumes a position of vital importance in prophylaxis. Several features of yellow fever make possible the successful application of maritime quarantine. These are: The short period of incubation; the absence of chronic cases; its prevalence in endemic form in only a few places which have communication by water with important ports and centers of population. The interception of most cases that reach points of debarkation is thus made possible. The weak link in the chain is the existence of very mild cases. The efficiency of maritime quarantine is greatly increased by having medical officers of the Public Health Service stationed at ports of embarkation in the yellow fever zone. Ships should not be allowed to clear from infected ports without inspection by these officers.

Systems of land quarantine, including railway quarantine and the sanitary cordon, have rarely, if ever, been successful.

Delay in recognizing the early cases is most dangerous, as it may lead to rapid multiplication of the infected centers. This happened in New Orleans in 1905. In many cases the diagnosis is not easy. Able diagnosticians must be employed and house to house visitations made to determine the extent of the outbreak. It may safely be assumed that mild cases are being treated as malaria, dengue, or influenza. When an outbreak occurs in a place it can be taken for granted that the importation took place two or three weeks prior to the discovery of the first cases. All cases of fever of any kind should be reported to the central sanitary authorities, who should have authority to screen promptly or deal with them otherwise as the diagnosis warrants. When a case is detected it should be screened immediately and effectively or removed to a well-screened hospital. In the latter instance it should be protected by a mosquito net while awaiting transportation and while *en route* to the hospital. In places in or near the endemic areas or in localities confronted by actual or threatened epidemics, all habitations, places of business, and public buildings should be rendered mosquito-proof by the most approved methods of screening. Imperfect screening as well as other sanitary offenses such as the presence of mosquito larvæ, accumulation of water, etc., on one's premises should be punishable by fines.

The adult mosquitoes are best destroyed by sulphur dioxide, or in case this is impracticable or undesirable pyrethrum or some other insecticide may be used. The fumigation is best done between the hours of 9 A.M. and 3 P.M., the quiescent period of *Aëdes calopus.*

Before a systematic campaign for the eradication of mosquitoes and their larvæ and the destruction of their breeding places is entered upon, a careful sanitary survey of the infected or threatened district should be made. To be effective, not only general measures such as draining, filling, ditching, and culicides must be utilized in a campaign, but special efforts must be directed against the domestic breeding places of *Aëdes calopus.* All puddles and stagnant pools must be abolished, and water tanks, barrels, butts, and cisterns must be kept covered with metallic screening, twenty meshes to the inch.

In a locality not habitually a yellow fever center the plan of evacuation is sometimes feasible. All the inhabitants except the immune and those caring for the sick are removed from the infected area and placed in a quarantine camp for thirteen days. The area is isolated and all the mosquitoes and their breeding places destroyed.

Low-lying districts and other localities likely to contain the breeding places of Stegomyia should be avoided. The upper stories of houses are safer for sleeping purposes, as they are less frequented by mosquitoes than the ground floor.

Military. A military or naval force has in itself or at its command three elements very necessary in successfully combating yellow fever, viz., authority, the coöperation of the intelligent members of the community, and resources. This was well exemplified in Havana in 1901 under the administration of General Leonard Wood. Under military government, in times of peace or of suspended hostilities, the prophylaxis of yellow fever is comparatively easy. How effective the well-proven prophylactic methods could be made in an infected area under war conditions is problematical. The disease would probably be easier to avoid or eradicate during a campaign than malaria. Only grave military necessity, such as called for the Santiago Campaign in 1898, should warrant the sending of a military expedition into an infected district.

Before occupying any building in the yellow fever zone it should be well fumigated, preferably with sulphur dioxide, in order to insure the destruction of all insect life. Soldiers should be prohibited from entering houses or shops, especially at night. The regulations as to the use of mosquito nets must be rigidly enforced, and the breeding places of Stegomyia in the post or camp and the immediate neighborhood searched for and destroyed.

When the disease is endemic or epidemic in the surrounding population the most careful quarantine must be established. Military necessity should be the only reason for soldiers being in localities where they are in danger of being bitten by infected mosquitoes. The men should be instructed regarding the danger from mosquito bites. Arrivals from a known focus of yellow fever should be quarantined in a screened detention ward for five days.

Cases occurring among the troops should be immediately placed in a well-screened hospital or tent. When a command becomes infected it is desirable to evacuate the camp or post and, if possible, transfer the men to a cooler or higher district. Moving a camp a mile or two into a locality free from Stegomyia will, at times, avert an epidemic.

Naval. At shore stations the naval forces are protected by the same means as the army. When a force is landed from a ship or fleet the same precautions should be observed as far as possible. At least, mosquito nets should be furnished and the men required to use them.

The general precautions necessary to avoid mosquito-borne infections are given in the section on "Naval Sanitation."

If the disease is prevalent on shore there should be no liberty whatever. Only officers and the most trustworthy men should be sent ashore on official business, whenever possible returning to the ship before 1 P.M. No covered or partly covered shore boats should be allowed alongside, as mosquitoes may be received from boats or tugs, as was probably the case with the U. S. S. *Yorktown* at Guayaquil, Ecuador, in January, 1912. No bunches of bananas should be brought aboard, as these have been known to harbor Aëdes. Only in exceptional cases should supplies from shore be brought to the ship. No bumboats should be allowed to supply the ship.

On board, no water should be left uncovered, as any so exposed offers a breeding place for Aëdes. The ship's boats must be kept carefully dried out. A daily inspection should be made of water-containing vessels such as fire buckets and division tubs. A careful search should be made for such containers as empty bottles, water pitchers, and slop jars in unoccupied rooms, and especially the bilges under the fresh-water tanks. Men should be detailed to search for and kill all mosquitoes that may be on board. The search will be most successful if conducted in the forenoon and particular attention is paid to dark corners. Light-colored paint on bulk-heads and ceilings aids this materially, as the insects may be seen more readily. During the rainy season in the tropics it is very difficult to keep ships dry, and it may be necessary to use kerosene in water ways, boats, and places difficult of access where mosquitoes might breed.

In the presence of a threatened or actual epidemic it is of vital importance to make an early differential diagnosis of every case of elevated temperature. The temperatures of the entire ship's company should be taken daily, as this is the only method of detecting the early stages of the disease. Serious spread of yellow fever may follow non-recognition of the early cases, as was the case on the U. S. S. *Boston* at Panama in 1905.

If a case of yellow fever occurs on board it should be assumed that Aëdes are present. If the case originated on the ship the infected insect is or has been present. The sick should be transferred to a hospital on shore or to a mosquito-proof ward of a hospital ship as soon as possible. Every subsequent case of fever must be protected from mosquitoes by nets or screening and kept under close observation until the diagnosis is cleared up. The ship must be thoroughly fumigated, preferably with sulphur dioxide. If possible, it should be taken to a quarantine station for fumigation. If this is not feasible she should put out to sea, and, if the insecticides are available, fumigated under way. If the disease occurs at sea it is best to run into cold latitudes. Make use of such insecticides as may be on hand for the fumigation of that part of the ship from which the case came. Tobacco may be used as an insecticide in an emergency. The ship must be thoroughly opened and aired, all mosquitoes searched for and killed, and a quarantine station where fumigation may be done reached with as little delay as necessary.

Ships are probably as open to infection by yellow fever as ever, but modern naval construction facilitates their fumigation, and their high speed renders their return to a cooler climate a simple matter.

Prophylactic measures against yellow fever and malaria are founded upon the same principles, but their practical application differs, owing to differences in the habits of the two mosquitoes and to differences in the two diseases. The yellow fever problem is relatively easy, as Aëdes are not hard to reach, their breeding places being practically confined to artificial containers in the neighborhood of human habitations, while those of Anopheles are found in pools, marshes, or streams, and often in collections of water in the brush or grass. The Anopheline breeding places frequently cover wide districts, and are rather hard to find and difficult to destroy. Aëdes is a domestic mosquito, while Anopheles is a traveler. The period of communicability of yellow fever in man is only three days; the malarial parasites may remain in the circulating blood for months or years. No medical prophylactic is known for yellow fever; while quinine is an efficient preventive measure for malaria.

General Gorgas has stated that mosquito extermination is not necessary to eradicate yellow fever. If their numbers are much reduced the chain of infection is sure to be broken.

Dengue

Synonyms. Dandy fever, break-bone fever, neuralgic fever, three-day fever, giraffe fever, breakheart, broken wing, fievre rouge, arthrodynie, knokkelkoorts, febris endemica cum roseola, exanthesis, arthrosia, calentura (Philippines colloquialism).

Definition. An acute, infectious disease occurring epidemically and endemically in warm countries. It is characterized by two febrile paroxysms separated by an interval, pains in the bones, joints, and muscles, and by an eruption which appears about the third or fourth day.

Historical Notes and Geographical Distribution. The disease was first recognized and described about 1780 during an extensive epidemic that extended through the East Indies, Southern Asia, Northern Africa, and Spain. About the same time it prevailed in America as far north as Philadelphia and New York. Benjamin Rush wrote a classical description of dengue dating from this time.

Dengue has a tendency to assume pandemic characteristics about every twenty years. There have been many epidemics in the Gulf States, the last one being in 1897, when the diagnosis was confused with that of yellow fever.

Ashburn and Craig of the Medical Corps of the United States Army, in experimental work at Manila in 1907, demonstrated that the disease could be transmitted by injections of blood, filtered and unfiltered.

Dengue is endemic in many tropical and subtropical countries and few localities with a warm climate have escaped its visitations. It is found in Central and South America, the West Indies, the islands of the Pacific, especially the Hawaiian and Philippine groups, Southern Asia, the East Indies, and Asia Minor. Epidemics occur from time to time in the Ægean Archipelago, Egypt, Zanzibar, Mauritius, South Africa, and Australia.

Predisposing Conditions. The presence and opportunity for breeding of culicine mosquitoes, hot weather or season, low altitudes, and recent arrival in an infected locality are the chief predisposing conditions.

This disease has no respect for age, sex, or condition in life. New arrivals are particularly prone to an attack. In the Philippines dengue is looked upon as a routine feature of life in the first few months in the islands.

Infectious Agent. A filterable virus.

Source of Infection. The blood of infected persons.

Dissemination. By the bite of infected mosquitoes. There seems to be a general acceptance of the idea that dengue is transmitted by the common culicine mosquito of the tropics, *Culex fatigans.* More recent work (Australia, 1916) points to *Aëdes calopus.* Other species of Culicinæ, including *Culex microannulatus,* have been incriminated.

Portal of Entry. Through the skin by bites of the infecting mosquitoes.

Incubation Period. Four to five days.

Period of Communicability. During the febrile stage of the disease.

Immunity. Some people have a natural immunity, but this is exceptional. A certain degree of acquired immunity of unknown duration is conferred by an attack.

Prophylaxis. This rests entirely upon the destruction of mosquitoes, the screening of all patients to prevent mosquitoes from becoming infected, and the use of screening, mosquito bars, and other measures to prevent healthy individuals from being bitten.

In dengue the virus is apparently in the blood for four or five days, so that screening of patients is necessitated for a longer period than for yellow fever or Phlebotomus fever. (Stitt.)

Filariasis

Definition. Infestation with long, thread-like nematode worms known as filaria. The adult worm lives in the connective tissue, lymphatics, and body cavities. The embryos or larvæ are found in great numbers in the blood. The most important filariæ of man are:

(1) *Filaria bancrofti,* the larva of which is known as *Filaria nocturna,* appearing in the blood at night and occurring in all tropical countries, including the warm parts of America.

(2) *Filaria loa,* the larva of which is known as *Filaria diurna,* occurring in the blood by day and prevalent in West Africa and India.

(3) *Filaria perstans,* the larva of which is known as *Filaria perstans;* is widely distributed, especially in West Africa.

None of the young worms do any great amount of injury in the blood. One of the adult worms, *Filaria bancrofti,* causes a serious disease, elephantiasis. The second species, *Filaria loa,* is more or less troublesome. There is the possibility that the other species cause ill effects of which we are not as yet aware.

Geographical Distribution. Filaria infest man throughout the tropical and subtropical world. In the United States it is not common, but is observed as far north as South Carolina. In some of the islands of the Pacific, especially Samoa and the Fiji Islands, it is very prevalent. A large proportion of the natives show the *Filaria nocturna* in the blood.

Predisposing Conditions. Residence in the endemic area and exposure to the bites of the transmitting mosquitoes.

Source of Infection. The blood of infected persons.

Dissemination. *Filaria bancrofti* is transmitted by mosquitoes, *Culex fatigans* and *Stegomyia pseudoscutellaris. Filaria loa* is transmitted by a species of biting fly, *Chrysops.* The transmitting agent of *Filaria perstans* is not surely known; mosquitoes and ticks are suggested.

Filaria may be disseminated by modes unknown to us. Manson states that this would be hard to prove and rash to deny.

Portal of Entry. According to our present knowledge, through wounds in the skin made by the bites of the transmitting insects.

Incubation Period. Indefinite.

Period of Communicability. During the continuance of the embryo parasites in the peripheral blood of the infected persons.

Prophylaxis. Preventive measures are based upon the theory that filariasis is a mosquito-borne disease. However, other possible modes of transmission must not be overlooked. Means of control, therefore, depend upon the suppression of the mosquito and the prevention of mosquito bites. These measures must be along general lines and include a combination of those described under malaria and yellow fever and personal hygiene and general sanitation.

Fleas

Plague

Synonyms. Bubonic plague, black death, the pest.

Definition. A specific, inoculable, and otherwise communicable disease common to man and many of the lower animals. It is characterized by fever, adenitis, a rapid course, a very high mortality, and the presence of the specific bacterium in the lymphatic glands, viscera, and blood. In a large proportion of cases buboes form in the groins, arm-pits, and neck.

Historical Notes and Geographical Distribution. Plague was not described by the classical Greek writers on medicine, though it seems to have been known in early times. The destruction of the Assyrian army under Sennacherib, recorded in the Book of Kings, has been ascribed to the plague. "Small animals of the field" died at the same time. Some authors state that the Plague of Athens, during the Peloponnesian War, was the pneumonic form of plague. The first accurate description of it dates from the second century before the Christian Era.

History records four great pandemics of the disease: the Plague of Justinian in the sixth century, the Black Death of the fourteenth century, the Great Plague of the seventeenth century, and the recent pandemic.

The Plague of Justinian ravaged the known world. It started at Pelusium in Egypt, A. D. 542, spread to Byzantium, thence into Asia, and via Northern Africa into Western Europe as far as Ireland. It lasted in epidemic form about two hundred years.

The Black Death, or the Great Pestilence, originated in China, where probably thirteen million people died. Twenty-four million succumbed in other parts of the Orient. It reached Europe in 1348, entering the seaports of Italy and southern France by way of the north coast of the Black Sea and Constantinople. It is estimated that nearly half of the inhabitants of Europe fell victims to the scourge. This epidemic was accompanied by great religious excitement and fanaticism, especially in Germany. It was indirectly of benefit to the working classes of England as the dearth of laborers caused wages to be nearly doubled. This is the pestilence referred to by Chaucer and Boccaccio. At this time the Venetians laid the foundations of modern prophylaxis by instituting the quarantine for forty days, hence the term. They compelled the ships from infected ports to hoist a yellow flag and the passengers and crew to undergo inspection.

Plague seems to have lurked in corners of Western Europe from the fourteenth to the seventeenth century, when in 1664-65 it flamed up, especially in England, where it received the name of the Great Plague. Seventy thousand persons died in London alone. After this it suddenly left Western Europe, but lingered in Eastern Europe until our own times, 1884.

The recent pandemic started from Yunan, in southwestern China, in 1894. This province borders on Thibet and Farther India and it is probable that plague has been endemic there since late in the eighteenth century, possibly having been introduced by Mohammedans returning from Mecca via Burma. It spread to Canton and Hongkong, thence along the trade routes to all the ports and through the interior of the southern provinces of China and to Japan, the Philippines, Indo-China, Straits Settlements, Siam, Farther India, and India, where it still smolders, occasionally flaring up in epidemic form. From India it spread to Mauritius, Madagascar, and South Africa. By other trade routes it extended to Sidney and Brisbane in Australia and Alexandria in Egypt. In Europe many ports, especially on the Mediterranean, became infected and a few epidemics occurred. From Europe it reached the east coast of South America. The first cases to reach the United States were brought to New York Quarantine in the spring of 1900 from Santos, Brazil. Honolulu and the West Coast of the United States were infected via the Pacific trade routes from China. The small localized epidemics that occurred in Honolulu, San Francisco, and Seattle were largely confined to the Chinese.

At present the endemic foci are the eastern and western slopes of the Himalayas; India, especially Bombay; central and eastern Arabia; Uganda, near the source of the White Nile in Africa; and in California, where the ground squirrels are infected.

Predisposing Conditions. The presence of plague among rats, mice, and other rodents predisposes and generally heralds the disease among the human inhabitants of a locality. It is essentially a disease of the lowest classes, as unhygienic living conditions, including sewage-polluted soil, filth, overcrowding, and extreme poverty are powerful predisposing factors. Age, race, and sex are apparently of no moment.

Plague is not necessarily confined to warm climates, but has become largely so of late years, due to advances in sanitation among the inhabitants of cold and temperate countries. The essential conditions for its propagation, filth and overcrowding, exist to a greater extent in warm countries.

The hot season in the tropics and the winter season in the temperate zones are hindrances to the spread of the disease. The reason for this appears to be the effect of temperature on the bacilli in the flea. They disappear rapidly from its stomach at 85° F. and are very ineffectual at that temperature. At 70° F. they are very virulent. High temperatures restrain the adult fleas from laying eggs and the larvæ from developing. A temperature of about 70° is best for the propagation of plague, though epidemics have occurred in Manchuria and Russia in winter and in Syria in summer.

Infectious Agent. *Bacillus pestis.*

Source of Infection. Blood of infected persons and animals, pus from buboes, and sputum of human cases of pneumonic plague. Outside the human body the bacillus is found in the excreta of plague patients and plague-stricken rats and other animals, in infected dust, and in the bodies of fleas, lice, and bedbugs.

Dissemination. Direct contact and droplet infection in the pneumonic form. In the other form the disease is generally transmitted by the bites of fleas (*Loemopsylla cheopis* and *Ceratophyllus fasciatus*), by which it is carried from rats to man; it is also carried by fleas from other rodents. Infection may be caused by the bites of infected animals, and accidentally, by inoculation.

Plague is primarily a disease of rats, human plague being an offshoot of this epizoötic. More rarely mice, ground squirrels, squirrels, swine, chickens, turkeys, geese, snakes, and jackals suffer from and carry plague.

While it is most frequently transmitted to man by fleas, there is strong evidence that lice, bedbugs, flies, ants, and roaches act at times as transmitting agents. These insects are mechanical, not biological, carriers of the disease. The bite is scratched and the bacilli from the excreta of the insect is rubbed into the wound. The human flea, *Pulex irritans,* occasionally bites rats and transmits plague, but the rat fleas are the most frequent factors in its transmission. The bacillus enters the body most frequently through wounds of the skin, either minute, as the bite of an insect, or larger, especially cuts and abrasions of the feet, but infection through gross wounds is rare.

The danger of droplet infection from pneumonic plague is very grave. As the bacillus is readily killed by drying and sunlight, the danger is not so great from indirect contact infection and almost negligible from fomites. Infection received from a case of pneumonic plague does not necessarily lead to the development of that form in the recipient.

Rat carriers are especially dangerous, as they may be killed at any time and their bodies infect other rodents or man. Mild and chronic cases among rats are of this class. These mild cases and true carriers among rats and also among men may play considerable part in the spread of plague. Atypical cases of the glandular type are rarely dangerous, but late suppuration may take place or lung symptoms develop and the victim become a focus of infection. Bacilli may continue to be thrown off from the lungs and from abscesses for two or more months.

Portal of Entry. Through wounds in the skin, generally the bites of fleas; the respiratory tract.

Incubation Period. Commonly from three to seven days, occasionally prolonged to eight or even fourteen days.

Period of Communicability. Until convalescence is well established, period undetermined.

Immunity. One attack usually protects for life; second attacks are occasionally reported.

Prophylaxis. General Measures. 1. Extermination of rats and vermin by use of known methods for their destruction; destruction of rats on ships arriving from infected ports; examination of rats, ground squirrels, etc., in areas where the infection persists, for evidence of endemic or epidemic prevalence of the disease among them.

2. Supervision of autopsies of all deaths during epidemics.

3. Supervision of the disposal of the dead during epidemics, whether by burial, transfer, or holding in a vault, whatever the cause of death.

4. Cremation, or burial in quick lime, of those dying of this disease.

The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms, confirmed by bacteriological examination of blood, pus from glandular lesions, or sputum.

2. *Isolation.* Patient in hospital if practicable; if not, in a screened room which is free from vermin. In plague pneumonia, personal prophylaxis, to avoid droplet infection, must be carried out by persons who come in contact with the sick.

Masks or veils of cheesecloth should be worn as protective measures.

3. *Immunization.* Passive immunization of known exposed contacts; active immunization of those who may be exposed.

4. *Quarantine.* Contacts for seven days.

5. *Concurrent Disinfection.* All discharges and all articles freshly soiled therewith.

6. *Terminal Disinfection.* Thorough cleaning followed by thorough disinfection.

Military. The prevention of plague in military life is based upon the same principles that guide the civil sanitarian. The sanitation and police of the camp, cantonment, or garrison should approximate the ideal. A relentless campaign must be waged against all rodents, especially rats, mice, ground squirrels, and marmots. Every precaution must be taken to remove their food supplies, eliminate their habitats, and destroy them by traps, poisons, and natural enemies. Fleas in barracks, cantonments, etc., are destroyed by scattering flake napthalin on the floors and closing the doors and windows for twenty-four hours.

A rigorous quarantine must be maintained against infected districts. Military forces or individual soldiers should occupy or visit threatened or infected areas only on duty or because of military exigencies. No one in the command or living under the jurisdiction of the military authorities should be allowed to go barefooted. Early diagnosis and isolation of cases is imperative. Protective inoculation is practicable and should be utilized.

Naval. When plague prevails on shore the crews of naval vessels should not be allowed shore liberty. Only trustworthy men should be allowed to go ashore and they only on duty. As rats are good swimmers, ships should be anchored well out, a mile if possible. Infected rats may swim to the anchor chain and come aboard through an unprotected hawse-pipe. When alongside the dock the mooring lines should be tarred or protected by inverted or circular tin rat-guards. The gang-plank should be triced up at night and during the day a man should be stationed at it to prevent rats from coming aboard.

All rats and mice aboard ship must be caught and destroyed. Frequent inspections should be made for fleas, bedbugs, and lice, and immediate measures taken to eradicate them. The men should not be allowed to go barefoot, thus avoiding wounds and abrasions of the feet.

If a case occurs, it should be isolated on the superstructure with a carefully instructed hospital corps man. The patient should be transferred as soon as possible to a hospital or hospital ship.

Ships entering plague-infected ports should be fumigated against vermin once every six months as a routine procedure. For this purpose hydrocyanic acid gas is unquestionably the best fumigant. Since the process has been perfected and standardized by the Public Health Service it may be quickly and safely done.

The successful prophylaxis of plague is based upon the full appreciation of the fact that it is a rodent disease, and that human infection is a sad but preventable incident of its prevalence in endemic or epidemic form among the rodent population. If man allows himself to come in intimate contact with these undesirable citizens it is his own fault if he is exposed to the danger of plague. It is now clearly recognized that the rat and other members of the genus *Mus* are the chief factors in the extension of the acute form of the disease, and that the ground squirrel, tarbagans, and other rodents of the genus *Marmota* are accountable for the perpetuation of plague in chronic form.

From the foregoing it is apparent that to prevent plague it is necessary to control the infection in both genera. When discovered among the *Murinæ* its control is a matter of immediate necessity. While measures against the disease among the *Marmota* may be proceeded with in a more leisurely manner, success in this case would have more far-reaching results, as the *Marmota* serve as reservoirs of plague in the periods between epidemics. If rodents are excluded from the habitations of man the danger of human infection is minimized. If rats are prevented from leaving plague foci the dissemination of the disease is checked. Control of plague among the *Marmota* renders impossible the spread of the disease to the *Murinæ,* and thus the chain of infection is broken. (Rucker.)

Fleas do not occupy the important position in the prophylaxis of plague that they do in the dissemination of the disease, nevertheless their exclusion and eradication from the home of man require thought and attention. It is assumed that if their chief hosts, rodents, are excluded, human habitations will be practically free from the insects.

Rucker arranges plague-prophylactic measures under the following heads:

1. The protection of the home of man against rats.
2. The prevention of the migration of plague.
3. The protection of rats against infection.
4. Immunization of the individual.
5. Periodic rodent surveys.

The details of the destruction of rats and fleas and of rat-proofing buildings, etc., is given in the section on "General Prophylaxis."

The crusade against rats has been almost world-wide, but has only proved partly successful. Efforts in Japan, Australia, the Pacific Coast States and the Gulf States have greatly diminished their numbers, but thus far there has not been recorded a single instance of their complete extermination. "The limitation of species is an important adjunct to eradicative work, because by reducing the number of rats their chances for personal contact and interchange of fleas is thereby rendered less probable. This brings about what is virtually a dilution of the infectable material, and if carried far enough will of itself stamp out plague in rats. As a purely prophylactic measure, however, wholesale rodent slaughter is not indicated. The all-important thing is to prevent the rat from gaining access to the home of man." (Rucker.)

Rats found dead as well as those killed or trapped should be tagged with a statement of time and place found, and examined bacteriologically for plague. The animals must be handled with heavy gloves or tongs to prevent scratches which might prove a means of infection. If the result of the examination is positive, active measures must be taken in the neighborhood at once. Extraordinary efforts must be made to clear the infected and threatened areas of rodents, insects, and other vermin. Such general cleanliness of persons and domestic animals, houses, streets, and communities should be encouraged and enforced as will reduce both mammalian and insect vermin to a minimum.

It is extremely important that rats be prevented from leaving plague foci. To this end it is necessary to supervise maritime commerce, to render ships inaccessible to rats, to exterminate them once they have gotten aboard a ship, and to prevent their landing from vessels, especially those clearing from plague-infected ports. To these ends periodic fumigation should be practiced, rat guards and other ship rat-proofing methods utilized, and ships built containing automatic apparatus for the capture of rats as soon as they come aboard.

The travels of rats within cities should be prevented by forcing them into the sewers by the rat-proofing of buildings, wharves, etc. Particular attention should be paid to preventing their migration from the water-front, where epizoötics of plague usually first appear.

It is in the shipping district that human cases are usually first discovered. They are very apt to occur among merchant sailors, or in sailors' boarding houses. This emphasizes the importance of rat-proofing all water-front districts, the special observation of passengers and crews from such localities, and the prohibition of shipping crews and giving shore liberty at infected ports. The emigration of rats is the chief cause of the dissemination of plague from such places. The danger from human cases is a minor one, but nevertheless requires thoughtful attention.

Assuming that rats are to remain as unwelcome guests, they should be kept healthy as far as plague is concerned. If they are prevented from migrating from plague foci, there is no danger of rats becoming infected in regions where the disease does not exist, provided they are not permitted to come in contact with other animals having the disease. Plague in rats is an accidental infection as in man, but spreads among them like wildfire, developing a rapidity of spread which is directly as the amount of infectable material, and the opportunity which they have for close association. In ground squirrels, tarbagans and allied species plague assumes a chronic character after the first preliminary outburst, but flames up whenever fresh fuel is added. This occurs when the disease is transferred to rats in the area where the life zones of the two species overlap. Plague can be prevented from spreading from one species to the other by the maintenance of a strip of land which neither of them is permitted to occupy. When the disease is stamped out in the endemic foci it will cease to be a menace of any importance to human beings.

General immunization of the population against plague by serum is impracticable because of its cost, the short period of immunity conferred, and the discomfort and danger incident to its administration. Its general use would engender a feeling of security not warranted by its temporary value, and would tend to defeat those more important prophylactic measures directed against the transmitting and disseminating agents themselves. Its usefulness is confined to the protection of laboratory workers and others who are in constant contact with plague material.

A relatively inexpensive but important preventive measure which may be adopted by communities is the periodic survey of the rodent population. A small force of well-trained trappers can secure a large number of rats from different parts of a city in a short space of time, and careful laboratory examination of these specimens will detect the presence of plague in the rat community before it has an opportunity to attack human beings. Plague among rats may be speedily stamped out at a comparatively small cost if discovered before it has gained great headway among them. Once it has claimed human victims the expense of eradication is very high, and the harm which commerce receives is great and far reaching. (Rucker.)

Lice

Typhus

Synonyms. Febris bellica, morbus castrensis, camp fever, ship fever, hospital fever, jail fever, putrid fever, petechial fever, spotted fever, tabardillo (Mexican), Brill's disease, typhus exanthematicus.

Definition. An acute, specific, febrile, infectious disease characterized frequently by an abrupt invasion and marked by a rigor, high fever, early nervous symptoms of great prominence, a maculo-petechial eruption appearing between the third and fifth days, and a tendency in non-fatal cases to a termination by crisis.

Historical Notes and Geographical Distribution. Typhus was definitely differentiated from typhoid fever by the American physician, Gerhard, in 1829. It was formerly very prevalent; now it is rare, except in countries and communities in which there are notoriously bad hygienic conditions. The disease has always accompanied wars, famine, and widespread destitution. It last prevailed in epidemic form in the United States in New York in 1892-93. Since then, except for a few sporadic cases in our seaports, typhus had been considered non-existent in the United States until Anderson and Goldberger of the Public Health Service demonstrated that the symptom-complex known as "Brill's disease" is in reality typhus fever, and that the typhus fever of Europe and the typhus fever or "tabardillo" of Mexico are the same disease. It is now apparent that typhus has been smoldering in New York for many years, certainly since 1896, when Brill first described cases of what was known as "Brill's disease." As observed in New York typhus is generally mild, but seems to be on the increase. Probably this mild type is present in other large American cities. Its recognition gives for the first time a rational explanation of a remarkable feature of typhus, namely, the occurrence of a few cases at long intervals of time from any other outbreaks, and any known foci of the disease. These mild forms are the missing epidemiological link between the so-called sporadic cases and outbreaks.

At present the disease prevails extensively with high mortality on the Grand Plateau of Mexico. Epidemics occur from time to time in certain parts of Ireland, in some provinces of France, portions of Russia, particularly Poland and the Baltic countries, the Barbary States and Egypt in North Africa, Persia, Central Asia, and Northern China.

During the recent war outbreaks have occurred in the various war zones, notably Serbia.

Predisposing Conditions. The presence of the transmitting agents, the body-louse and the head-louse, is the strongest predisposing factor. It is essentially a disease of crowded centers of population, whether temporary, as in armies, or permanent as in the slums of large cities. Lousiness and close personal contact are most frequent under those conditions. Human misery in all forms predisposes to it. Poverty, famine, personal filth, overcrowding, lack of fresh air, physical and psychical exhaustion, intemperance, cold weather by inducing overcrowding, inadequate clothing and shelter are conditions predisposing to its spread in epidemic form. The male sex is more frequently exposed. No race is exempt. No extensive epidemic has ever appeared in modern times except in association with widespread destitution and the excessive aggregation of numbers of poverty-stricken, starved, and otherwise morally and physically deteriorated human beings. The most cleanly or fastidious person, compelled to work in overcrowded and filthy surroundings, may occasionally be bitten by lice, and if the lice carry the virus, contract the disease. Before the method of transmission was understood typhus claimed a very heavy toll among the attending physicians and nurses.

Infectious Agent. *Bacillus typhi-exanthematici.* (Plotz.)

Source of Infection. The blood of infected individuals.

Dissemination. Transmitted from man to man by the body-louse (*Pediculus corporis humanis*), and by the head-louse. (*P. capitis.*)

Portal of Entry. Wounds in the skin from bites of the transmitting insects.

Incubation Period. Five to twenty days, usually twelve days.

Period of Communicability. Until thirty-six hours have elapsed after the temperature reaches normal.

Immunity. One attack, as a rule, bestows immunity for life.

Prophylaxis. General Measures. Delousing of persons, clothing, and premises during epidemics or when they have come or have been brought into an uninfected place from an infected community.

The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms; confirmation by bacteriological and serological examination of the blood (blood culture and Felix-Weill reaction).

2. *Isolation.* In a vermin-free room. All attendants should wear vermin-proof clothing.

3. *Immunization.* Claimed to be practicable by the use of vaccine. Not yet generally accepted.

4. *Quarantine.* Exposed susceptibles for twelve days after last exposure.

5. *Concurrent Disinfection.* None.

6. *Terminal Disinfection.* Destroy all vermin and vermin eggs on body of patient, if not already accomplished. Destroy all vermin and eggs on clothing. Rooms to be rendered free from vermin.

The destruction of vermin is described in the section on "General Prophylaxis."

Physicians and nurses whose duties take them into infected areas should avoid outer clothing which is liable to brush against the bedding, furniture, or other fixtures. The nurses' skirts should be short enough to clear the floor. Such articles as gloves, veils, leggins, and netting should be utilized to make the clothing vermin-proof. Rubber gloves should be worn. One-piece suits or union suits extending from the toes to the neck with attached gloves were worn by the American Commission in Serbia. Adhesive plaster may be used to cover the openings at the neck and wrists in case separate gloves are worn. The regular hospital gown and shoes are also worn. The hair should be clipped short and the head and face protected by a surgeon's cap and mask.

Military and Naval. All measures of prevention are centered on the suppression of the louse. These are discussed in the sections on "Military Sanitation" and "Naval Sanitation."

Trench Fever

Synonyms. Trench pyrexia, periodic one-day fever, Salonica fever.

Definition. A term used to include a great number of cases of continued, intermittent, irregular, and relapsing types of febrile attacks, occurring especially among men from the trenches or near them.

There have been practically no fatal cases, but through frequent relapses and debilitating effects it renders a certain proportion of men permanently unfit for military service, and was one of the greatest causes of disability in the allied armies during the recent war.

Geographical Distribution. While trench fever occurs much more frequently on the various battle fronts and immediately in the rear, it does occur in training camps and in hospitals at some distance from the front and in persons who have never been near the line of battle. It was especially prevalent in the allied armies in Flanders and France, but it also prevailed among the troops in the Balkans, Mesopotamia, and in the training camps in England. The German and Austrian troops likewise suffered from this malady.

Trench fever may have existed before, but it has not been either frequent or severe enough to attract the attention of the medical profession. In January, 1918, a commission of American medical officers, assisted by British officers, in a hospital behind the British lines began a series of experiments on sixty-six American volunteers from field hospitals and ambulance organizations to determine, if possible, the specific cause of the disease and its mode of transmission. Animal experiments had proved futile, as no susceptible animals could be found. The preliminary report states that no germ was discovered; that the virus is present in the blood of men with the fever; and that it is transmitted to healthy men by the body louse. The volunteers were inoculated by injecting blood from men with the fever and by allowing lice from trench fever cases to bite them.

Predisposing Conditions. Service under conditions where infestation with the body louse is liable to occur is the chief predisposing factor. Many medical corps men have been infected, as their duties take them into the trenches where lousiness is practically unavoidable, and also into the hospitals in caring for the trench-fever cases. Age and service, rank and duties are without influence.

Infectious Agent. Unknown; as the fever is relapsing a spirochete infection is suggested.

Source of Infection. The blood of infected persons.

Dissemination. Infectious agent transmitted by the body louse, *Pediculus corporis* (*Pediculus vestimenti*). Carriers may occur.

Portal of Entry. Through the skin by bites of the infecting lice.

Incubation Period. In the experiments above mentioned the disease developed after blood inoculation in from five to twenty days; after being bitten by infected lice the fever required from fifteen to thirty-five days to develop.

Period of Communicability. Undetermined.

Immunity. One attack apparently does not give protection against subsequent attacks.

Prophylaxis. The prevention and control of trench fever depend upon the suppression of the body louse, the details of which are given in the sections on "General Prophylaxis" and "Military Sanitation."

Ticks

Rocky Mountain Spotted Fever

Synonyms. Rocky Mountain fever, tick fever of the Rocky Mountains, black disease, blue fever.

Definition. An acute, endemic, non-contagious infection characterized by chills, fever, pains in the back and bones, and a macular eruption, which is sometimes hemorrhagic.

Geographical Distribution. It occurs especially in the Bitter Root Valley of Montana, the Snake River Valley of Idaho and in limited sections of the mountainous districts of Utah Nevada, Washington, Oregon, and California. In Wyoming it is more widely distributed.

Predisposing Conditions. Residence in the infected districts and occupations, such as stock raising, liable to bring one in contact with domestic animals such as horses, cattle, and sheep which may be infested with the infected ticks.

Infectious Agent. The virus is not filterable and is probably bacterial in nature.

Source of Infection. Blood of infected animals, and infected ticks.

Dissemination. By bites of infected ticks, *Dermacentor venustus* (*Dermacentor occidentalis*). The infection may be transmitted by the larva, the nymph, and both the adult male and female ticks. The infection is also transmitted hereditarily through the ticks to their larvæ. Different species of ticks collected from various regions (*Dermacentor marginatus,* Utah; *Amblyomma americanus linnæus,* Missouri; and *Dermacentor variabilis,* Mass.) are able to transmit the virus of Rocky Mountain spotted fever. This implies a possible danger that other localities may become infected.

Ticks, either in the immature or adult stage, have been found upon twenty species of mammals examined in and around Bitter Root Valley. The adult ticks infest the larger mammals including mountain goats, bears, coyotes, badgers, woodchucks, and possibly elk, deer, mountain sheep, rabbits, and domestic stock and pets such as horses, cattle, sheep, and dogs. The nymphs and larvæ are more frequently found on rodents. This class includes ground squirrels, woodchucks, chipmunks, pine squirrels, mice, and wood rats. The agility of the small animals does not permit the adult ticks to remain upon them. The rodents act as the reservoir of the virus; the ticks feeding on these rodents become infected; the domestic animals obtain the ticks from the pastures and other uncultivated land infested by wild animals, and men are bitten by the infected ticks thus transported. This mode probably accounts for a majority of human infections, but doubtless some infected ticks reach men by more direct routes from wild animals.

Portal of Entry. Through the skin by bites of the infected ticks.

Incubation Period. Three to ten days, usually seven days.

Period of Communicability. Has not been definitely determined, probably during the febrile stage of the disease.

Immunity. One attack yields immunity.

Prophylaxis. Preventive measures are directed entirely against the tick. The insects must be avoided in the endemic areas. A strong effort should be made to destroy all the insects in and about every case of the fever. Tick bites should be immediately cauterized with strong carbolic acid.

The eradication of Rocky Mountain spotted fever depends upon the suppression of the transmitting tick, *Dermacentor venustus,* a difficult and expensive undertaking. As the largest proportion of the infected ticks feed upon domestic animals, the chances of the infection of human beings will be greatly lessened if the animals are rendered tick-free by dipping, spraying, or some other method. Other measures proposed are as follows: Clearing and cultivation of tillable land; burning over of foothills and "slashings"; killing of small wild animals. Some success has been attained in the Bitter Root Valley by grazing sheep in the infected districts, for the reason that ticks die upon sheep, and many of the engorged females are not fertilized on account of the difficulty experienced by the males in propelling themselves through the thick wool in search of the females. (Rosenau.)

Relapsing Fevers

Synonyms. Febris recurrens, famine fever, tick fever, seven-day fever.

Definition. A group of specific infections caused by spirochætes, characterized by febrile paroxysms which usually last five or six days with remissions of about the same length of time. The paroxysms may be repeated three or even four times, whence the name relapsing, or recurring, fever.

European, Indian, American, and African forms are described, presenting clinically much the same features, but the parasites differ in certain peculiarities. (Osler.)

Historical Notes and Geographical Distribution. Hippocrates described the clinical features of relapsing fever quite accurately, though this knowledge seems to have been lost until the first half of the eighteenth century. The first modern accurate description of it appeared in 1739, though it is known to have prevailed in Ireland and other parts of Europe prior to that time. Numerous more or less extensive epidemics occurred during the next century. In 1844 it was brought by immigrants from Ireland to Philadelphia. The last epidemic appearance of the disease in the United States was in 1869. It prevailed in the Balkan States during the Balkan Wars in 1913-1914. Turkey, Russia, Ireland and other parts of Europe have suffered from many epidemics. It occurs in epidemic form from time to time in China, India, the Philippine Islands, the Dutch East Indies and other parts of the Orient. It is endemic in Egypt, Algeria, Uganda, and German East Africa. A relapsing fever occurs in Central America and Colombia.

Predisposing Conditions. War, famine, overcrowding, unhygienic conditions, and human misery generally, being favorable to infestation with the suctorial insects, are potent predisposing conditions.

Infectious Agent. In the relapsing fever of different countries, somewhat different varieties or strains of spirochœtæ have been found; thus the European relapsing fever is due to *Spirochœta recurrentis,* those of East and West Africa to *Spirochœta duttoni,* that of North Africa to *Spirochœta berbera,* the Indian to *Spirochœta carteri,* the Persian to *Spirochœta persica,* the American to *Spirochœta novyi.*

Source of Infection. The blood of infected persons. The spirochætes are in the peripheral circulation during the febrile period but not in the afebrile period.

Dissemination. The European relapsing fever is transmitted by lice and possibly by bedbugs; the relapsing fevers of East and West Africa are transmitted by the tick (*Ornithodorus moubata*); the North African relapsing fever is transmitted by body and head lice; the relapsing fever of Persia is transmitted by a tick of the genus Ornithodorus; the Indian and American varieties are transmitted by lice.

The spirochætes taken in by a louse disappear in a few hours and the insect remains harmless until the fifth day, when it becomes infectious, and so remains until the twelfth to fifteenth day. Spirochætes reappear in the cœlomic fluid of the louse about the sixth day, and continue present until about the twentieth day.

It is by crushing the louse, by scratching or otherwise, that the spirochætes contained in the cœlomic fluid reach and penetrate the wound of the bite. It is therefore a contaminative method of infection. (Stitt.)

The infection of man by the tick is also by the contamination method, material from the feces and coxal glands containing the spirochætes being rubbed into the wound made by the tick bite.

With tick fever the epidemiology rests upon the life history of the tick *Ornithodoros moubata.* The tick infests the rest houses along the route of travel, hiding in the crevices of floors and walls during the day and coming out at night to bite the sleeping inmates. The feeding occupies a long time, more than an hour. Both sexes bite man. The female lays about 100 eggs, from which a nymph emerges in about twenty days. The larval stage takes place in the egg. Shortly after emerging the nymphs suck blood. An important fact is that the female transmits the spirochæte to its ova, so that the ticks from such ova may transmit the disease. (Stitt.)

Portal of Entry. Wounds in the skin made by the infecting insects.

Incubation Period. This appears to be short; in some instances the attack develops within twelve hours after exposure; more frequently, however, from five to ten days elapse.

Period of Communicability. During the continuance of the spirochætes in the blood. The spirochætes disappear from the circulation when the temperature falls to normal. The disappearance of the parasites from the blood is brought about by the presence of antibodies (agglutinins and parasiticidal substances). In those cases, however, in which relapses occur, the blood remains infectious during the intervals. This is due to some parasites resisting the action of the antibodies.

Immunity. One attack does not confer immunity to subsequent infection.

Prophylaxis. This is based upon the eradication of the bedbug, tick, and louse, the details of which are given in the chapter on "General Prophylaxis."

Bedbugs

The Leishmaniases

Synonyms. For Indian kala-azàr: dum-dum fever, non-malarial remittent fever, cachectic fever, tropical splenomegaly, kala dukh. For infantile kala-azar: febrile splenic anemia, ponos. For the Eastern cutaneous leishmaniasis: Oriental sore, Bagdad boil, Aleppo boil, Biskra button, bouton d'Orient, granuloma endemicum. For the American cutaneous leishmaniasis: bubas Braziliana, espundia, uta, forest yaws.

Definition. A group of three diseases, consisting of two general infections and one cutaneous affection. The visceral leishmaniasis of adults or Indian kala-azar and that of young children or infantile kala-azar are now considered one and the same disease.

The visceral leishmaniases are characterized by a chronic course, marked splenic enlargement, progressive anemia, and emaciation together with leucopenia. The cutaneous leishmaniases can surely be differentiated from other tropical sores only by the finding of the leishman bodies in smears made from the granulomatous tissue of the sore. (Stitt.)

Geographical Distribution. Indian kala-azar is endemic in certain parts of India, especially the eastern part. At times it becomes epidemic. It is also prevalent in Arabia, Ceylon, Farther India, Indo-China and China. In North Africa it occurs in Egypt, the Sudan, and Algeria. Cases have been reported from Sicily, Crete, and other islands of the Mediterranean. Research will probably reveal other endemic centers.

Infantile kala-azar occurs in Southern Europe and in north Africa. It is probably endemic in other countries.

The cutaneous affection is found chiefly in north Africa, Asia Minor, Syria, Persia, and India. Cases are now reported from Italy, Greece, and New Caledonia. The American variety is found chiefly in Central America, Brazil, Peru, and the Guianas.

Predisposing Conditions. Residence in the endemic areas and exposure to the bites of transmitting insects.

Infectious Agents. Three species of protozoa of the genus Leishmania: For Indian kala-azar, *Leishmania donovani;* for infantile kala-azar, *Leishmania infantum;* for Oriental sore and American leishmaniasis, *Leishmania tropica.*

Source of Infection. For the visceral leishmaniases, the peripheral blood; for the cutaneous leishmaniases, the discharges and granulation tissue of the ulcerating sores.

Dissemination. Epidemiological evidence points to the transmission of Indian kala-azar by the bedbug. The disease, when epidemic, always spreads relatively slowly along channels of human intercommunication, and apparently is directly due to the introduction of an infected human being into the district. The class of people who are mainly affected are the poorer sections of the European and native communities, those most frequently living in infested habitations. There is no doubt about the infection of a dwelling, nor the capability of the disease spreading from one dwelling to another. The bedbug has not been experimentally incriminated.

Nicolle is of the opinion that the dog acts as a reservoir of *Leishmania infantum,* and that canine ectoparasites, such as fleas, may possibly serve as the transmitting agents to human beings. There is some experimental evidence sustaining this view.

The epidemiology of cutaneous leishmaniasis is very indefinitely known, and the proven facts in regard to its dissemination are very few. The fact that the sores almost always occur on the uncovered parts of the body would suggest transmission by some insect as the house-fly or mosquito rather than by the body louse, flea, or bedbug, as these latter show no special preference for the uncovered skin. Some authors have stated that the disease is transmitted by drinking water and have produced evidence which they claimed tended to incriminate some of the inorganic constituents. It has been suggested that the dog may be the reservoir of this virus as well as that of infantile kala-azar. The notion has also been entertained that lizards and snakes may serve as the reservoir of virus for Oriental sore and that certain species of Phlebotomus transmit the disease from these reptiles to man. Oriental sore is rather easily inoculable. The disease seems to occur naturally in the dog in infected American regions. There is some evidence that the American sore is transmitted by a Simulium. It is also claimed that a tabanid fly is the transmitting agent.

Portal of Entry. Probably through the skin by bites of transmitting insects.

Incubation Period. Various authorities have given it as from two to three weeks to several months. Manson reported a case that developed the initial fever ten days after arrival in the endemic area. The period of incubation of the cutaneous leishmaniasis is usually given as about two months, although in some cases it may be as short as a week.

Period of Communicability. During the continuance of the parasites in the peripheral blood and in the ulcerating sores of the respective types.

Immunity. An attack of visceral leishmaniasis is usually fatal. The natural infection of man with Oriental sore produces a rather lasting immunity.

Prophylaxis. Some measure of success has been attained in India through prophylaxis conducted on the line of bedbug extermination. Results have also been obtained by abandoning infected houses and establishing new ones for the non-infected villagers, which need not be more than 300 yards from the old ones, thus showing that mosquitoes and flies are probably not concerned in the transmission of Indian kala-azar. Bedbugs are often so deeply located in cracks of thick-walled houses that they may not be reached by sulphur fumigation. Flaming of such crevices with a plumber's lamp has been recommended. (Stitt.)

The protection of abrasions and open wounds with flexible collodion or other protectives so as to prevent flies and other insects, which may have fed on Oriental sores, from having access to the wound, and the painting of insect bites with tincture of iodine are about all that can be recommended in the prophylaxis of cutaneous leishmaniasis.

Castellani and Chalmers suggest the destruction of all infected dogs in the endemic region as a preventive measure against infantile kala-azar.

Flies

The Trypanosomiases

Synonyms. Sleeping sickness, negro lethargy, sleeping dropsy, morbus dormitivus. For the Brazilian trypanoso miasis, Schizotrypanosomiasis, Chagas' disease.

Definitions. The African trypanosomiases are acute or chronic infections characterized by an inflammatory condition of the lymphatic system leading to meningo-encephalitis and meningo-myelitis.

In Brazil there is a disease caused by a flagellate, *Schizotrypanum cruzi*, which resembles a trypanosome and is transmitted by a bug, *Lamus megistus*. The disease runs an acute course with a high fever and great mortality among infants, showing chiefly manifestations of involvement of brain or thyroid gland. In adults it runs a chronic course, showing neurological manifestations or signs of myxedema or even Addison's disease. (Stitt.)

Geographical Distribution. The African trypanosomiases or the sleeping sickness prevails on the West Coast of Africa, in the basin of the Congo, in Uganda, and in Rhodesia. The disease in Rhodesia is similar to but more virulent than that found in the other districts, but the parasites and transmitting flies of both are closely allied species.

Brazilian trypanosomiasis is endemic in the state of Minas Geraes.

Predisposing Conditions. Residence in the infected districts and exposure to the bites of the transmitting flies are the essential predisposing factors.

Infectious Agents. African: *Trypanosoma gambiense* causes the disease in Uganda, the valley of the Congo and on the West Coast; *Trypanosoma rhodesiense* is the infectious agent in Rhodesia. The Brazilian trypanosomiasis is caused by *Schizotrypanum cruzi*.

Source of Infection. The blood of infected persons.

Dissemination. African trypanosomiasis is transmitted by two species of tsetse flies, *Glossina palpalis* and *Glossina morsitans*, the latter transmitting the Rhodesian type of the disease. The trypanosome undergoes a developmental cycle in the fly, which does not become infective until after about twenty days. Male and female flies bite man and transmit the parasites. They bite in the daytime, usually from 9 A.M. to 4 P.M., and will bite in the sunlight. The flies are credited with being attracted by persons wearing khaki-colored clothing.

There is some evidence that trypanosomiasis is transmitted by sexual intercourse. Possibly healthy carriers act as reservoirs.

The fact that infected flies have been caught in districts that have been depopulated for more than a year, in the hopes of eradicating the disease, lends strength to the view that there is some other reservoir than man. The trypanosome strain in the antelope is the same as *Trypanosoma rhodesiense* and both are transmitted by *Glossina morsitans*. Crocodiles have also been suggested as a possible reservoir of the parasites.

The Brazilian trypanosomiasis is transmitted by a bug, *Lamus megistus,* in which the parasite undergoes a cycle of development. Both the male and female of *Lamus* bite and can transmit the disease, and, although the parasite cannot be transmitted hereditarily, the nymph is capable of sucking blood and becoming infected.

Portal of Entry. Through bites in the skin made by the transmitting insects.

Incubation Period. In the African trypanosomiases the period is about two or three weeks. In the Brazilian form it is about ten days.

Period of Communicability. As long as the parasites are present in the blood of the patient.

Prophylaxis. At the present time prophylaxis must be undertaken on the assumption that the disease is spread from place to place by man along channels of human intercommunication, and from man to man by *Glossina palpalis* and *Glossina moristans,* and that at least in the case of *Trypanosoma rhodesiense* there are animals which act as reservoirs of the virus.

SUMMARY OF PROPHYLACTIC MEASURES. I. *General Measures.* 1. Coöperation of various governments.

2. Formation of medical posts of inspection at suitable places to prevent infected natives from entering non-infected areas.

3. Segregation of the sick, if possible, in districts free from Glossinæ, or where the climatic conditions are unfavorable for the development of the trypanosome in the fly.

4. Clearing of the brush near villages and along the water's edge, especially at landing places, fords, and ferries.

5. In certain cases—especially with regard to *T. rhodesiense* —the destruction of large game, especially antelopes. (This is still *sub judice.*)

II. *Personal Measures.* 1. Avoidance of bites by wearing white clothing, high boots, puttees, and the puttee pattern of leggings.

2. Immediate disinfection of a bite by painting it with tincture of iodine or by applying a solution of formalin (1 in 40).

The foregoing summary is from the "Manual of Tropical Medicine," by Castellani and Chalmers.

Pappataci Fever

Synonyms. Sandfly fever, phlebotomus fever, three-day fever, summer fever.

Definition. An acute specific fever, lasting three days, and characterized by nervous symptoms, pains in various parts of the body, and gastro-intestinal disturbance.

Geographical Distribution. It occurs in all the countries bordering on the Mediterranean and Adriatic Seas, Egypt, Mesopotamia, India, and South America. Further research may show that it is cosmopolitan in its distribution.

Predisposing Conditions. It occurs only in warm climates and in the summer months in temperate climates. Its distribution is correlated with that of *Phlebotomus papatasii.*

Infectious Agent. A filterable virus.

Source of Infection. The blood of infected persons.

Dissemination. The transmitting agent is a moth midge, *Phlebotomus papatasii.* The female alone bites, chiefly at night. Six or eight days must elapse after feeding on a patient in the first day of the disease before the midge is capable of transmitting the disease. This is in accordance with the twelve-day developmental cycle of the yellow fever virus in the mosquito.

Portal of Entry. Bites in the skin made by the infecting flies.

Incubation Period. From three to seven days.

Period of Communicability. The first twenty-four hours of the illness. The virus seems to be only in the blood of the patient's peripheral circulation during this period. How long the fly remains infective is not known with certainty, as it usually dies after ten days' activity, but it is probable that the disease is transmissible to young broods of flies.

Immunity. An attack confers a fair immunity.

Prophylaxis. This consists in the general use of screens to prevent the transmitting fly from biting, the screening of all patients, especially during the first two days of the disease, and attempts to destroy the insect. As the Phlebotomus fly is very small, ordinary mosquito bars and netting will not keep it out. Netting with very fine meshes, such as cheap lawn, should therefore be used. The larvæ of the insect are very hard to find and destroy, as they are laid in damp garden earth. The little fly bites only in darkness and only in houses. Fumigation of rooms with pyrethrum or some other insecticide may be tried.

Chapter V

WOUND INFECTIONS

Suppuration and Sepsis

Definitions. Suppuration is the liquefaction of the products of inflammation with the formation of pus.

Sepsis or ''blood poisoning'' includes a group of non-specific infections known as sapremia, septic intoxication, septicemia, and pyemia, caused by a number of microörganisms, of which the pyogenic cocci are the most important. These infections are characterized by fever, chills, leucocytosis, frequently a severe intoxication, and at times foci of suppuration. The first two are due to the presence of toxins alone in the blood (toxemia), the last two are caused by the presence of toxins and bacteria (bacteremia).

Geographical Distribution. The germs of pus are ubiquitous, being found wherever men and animals live.

Predisposing Conditions. Constitutional diseases such as diabetes and nephritis predispose to suppuration and sepsis. Tissues that are bruised and lacerated or cut are prone to infection with the pyogenic organisms.

Infectious Agents. The organisms and toxins causing sepsis are of many varieties but in this section sepsis will be considered in a restricted sense as referring to infection with pyogenic bacteria and toxins.

The most common organisms generating pus are *Staphylococcus pyogenes aureus* and *Streptococcus pyogenes.* There are a number of varieties of each of these cocci. *Bacillus pyocyaneus,* which produces green or blue pus, is frequently present in wounds and ulcers which are not dressed regularly. Other pathogenic bacteria are occasionally found in suppurative processes.

Source of Infection. The pus from infected lesions and the articles soiled therewith.

Dissemination. Pyogenic infections are spread by every known means, but direct and indirect contact by hands, instruments, etc., is the most usual method. Water is almost invariably infected. Every living being is a carrier. Insects transfer the germs. Practically all objects are contaminated fomites.

Portal of Entry. Pyogenic bacteria generally enter the tissues through wounds, gross or minute. They do, however, make their way through hair follicles, sebaceous glands, or sweat ducts. When suppuration occurs or sepsis originates in a subcutaneous lesion such as a hematoma, the germs reach the damaged tissue through the blood, probably entering the circulation by means of the tonsils, lungs, or intestinal canal. The organisms enter the uterus following labor, miscarriage, or abortion. Mucous membranes often admit the germs, being less protective than the skin. Pathogenic and normally benign bacteria, constantly present in the intestines, lodge in local lesions (typhoid and dysenteric ulcers, etc., or catarrhal inflammation) and cause systematic infection. The infectious agents may enter through the throat after tonsillitis, diphtheria, or scarlatina, or through the middle ear.

Incubation Period. From less than twenty-four hours to three or four days, rarely longer.

Period of Communicability. As long as the pyogenic bacteria are discharged from the infected lesion or focus.

Prophylaxis. This is based upon the scrupulous observance of the principles and details of aseptic and antiseptic surgery. All wounds accidentally received should be carefully disinfected, preferably with tincture of iodine. Before operations the resistance of the patient should be increased by proper treatment. Aseptic and antiseptic precautions must be observed before, during, and after operations and the delivery of pregnant women. After labor care must be taken that none of the placenta is left behind. It is well to curette the uterus after miscarriage.

Military. The best method yet developed for the treatment and prevention of wound infections is the Carrel-Dakin method. It was applied first to old, infected wounds, and later to recent ones as a preventive measure. The method is based upon the assumption that surgical infection, at the outset, is always local, and in war wounds is carried by projectiles, and especially by fragments of clothing impregnated with microörganisms. The question then is simply how to destroy the microörganisms without harming the tissues. As a difference of resistance exists between the tissues provided with a circulation, on the one hand, and microbes, isolated anatomical elements and necrosed tissues, on the other hand, it is useless to seek a substance which would exercise an elective action on microörganisms. Better to seek for a given antiseptic, that degree of concentration of the solution and length of time during which it must be applied, which, though fatal to microbes, will not produce obvious damage to the tissues. The method is one of chemotherapy, and is the result of Dakin's studies of the action of many different antiseptics on tissues and microörganisms. Chloramines and hypochlorite of soda were the chemicals finally selected, as they are endowed with feeble irritating qualities, with a toxicity almost *nil,* but with considerable bactericidal power. Research has demonstrated that the microbes disappear if the antiseptic remains in contact with the surface of the wound at a certain degree of concentration during a prolonged period.

The following *résumé* of the principles and technic of the method is taken largely from "Notes for Army Medical Officers," by Sir Thomas H. Goodwin, Director General, Army Medical Service, British Army.

The method aims at rendering the wound germ-free within a week or ten days. Success depends on the closest attention to details and to antiseptic precautions.

An essential preliminary is the free excision of all infected or devitalized tissue and the removal of all foreign materials. All hemorrhage must be arrested. This preliminary mechanical procedure is followed by the introduction into and maintenance in the wound of the hypochlorite solution in sufficient amount and strength to destroy any organisms present. To insure success this solution must flow into every corner of the wound. For this reason through-and-through drainage tubes must be avoided, as these will favor escape of the solution. In contact with the tissues the solution soon loses its bactericidal qualities and must be renewed not less frequently than every two hours. This is effected by means of Carrel's appliance of a series of rubber tubes. The solution employed is Dakin's. This must be neutral and must not be warmed or diluted. The fresher it is the better, and it should not be kept longer than one week. Rubber tube, size No. 7, is employed. The distal end of each tube is closed by ligature. Numerous lateral small openings perforate the tube for two-thirds of the length, which is buried in the wound. The tube may be bare, or may be surrounded by stitched gauze or cloth. This latter method is advisable, when cases are being transferred, as it renders the tubes less liable to shift their position.

The tubes must be carried into every recess of the wound.

The outside dressing consists of several layers of gauze wrung out of the antiseptic solution. This dressing should be changed every twenty-four hours.

The solution may be instilled into the wound by gravitation or by means of a syringe.

In a hospital the better method is to suspend a glass container 2½ feet above the level of the bed and relax the clip on the delivery tube every hour or two, releasing an amount of solution, varying according to the extent and depth of the wound.

The process of disinfection is controlled by microscopic examination of smears every third day. When, in every field examined, not more than one microörganism is discovered, the wound may be closed.

The preparation, testing, and titration of the solution must be carefully carried out by one who is thoroughly trained in the necessary technique.

The method is equally applicable to the wounds received in industrial accidents and in naval warfare.

Erysipelas

Synonym. Saint Anthony's fire.

Definition. An acute communicable disease of the skin and occasionally of the mucous membranes, accompanied by fever and toxemia.

Geographical Distribution. Erysipelas is quite uniform in its distribution throughout the temperate zone in both hemispheres. It occurs with some degree of frequency in cold countries, as Iceland, the Faroe Islands, and Greenland. It is not uncommon in subtropical countries, but is comparatively rare in the tropics.

Predisposing Conditions. All forms of general debility, such as chronic alcoholism and kidney affections, favor the development of erysipelas. It is most prevalent in the spring. Certain persons have a natural predisposition and suffer from repeated attacks, the very young being more liable to the infection than adults, and males being more predisposed than females. Unhygienic conditions in hospitals and institutions favor the development of erysipelas in epidemic form. Susceptibility is specially marked in persons with wounds or abrasions of any sort, recently delivered women, and persons who have been the subjects of surgical operations.

Infectious Agent. Erysipelas is nearly always due to *Streptococcus hæmolyticus.*

Source of Infection. Discharges from the infected wound and articles, such as surgical dressings, recently soiled therewith.

Dissemination. It is conveyed by direct contact, indirect contact as by a third person, by fomites, and infrequently by unclean instruments and contaminated vaccine. Cases of placental transmission to the fetus are known. The virus adheres to clothing and furniture with great tenacity.

Portal of Entry. The infecting microbe is inoculated through lesions of the skin or mucous membrane. While infection through sound skin or mucous membrane is possible, it is probable that in the vast majority of cases of so-called idiopathic erysipelas the abrasion is so slight or is so situated, for instance just within the nostril, as to escape detection.

Incubation Period. This varies from a few hours to three to seven days.

Period of Communicability. As long as the infecting organism remains in the discharges from the wound.

Prophylaxis. General. 1. The infection of wounds and labor cases is avoided by the careful observance of aseptic and antiseptic surgical and obstetric procedures. (See subsection on "Sepsis.")

2. During an epidemic none but imperative operations should be performed. Those attending, nursing or dressing erysipelas cases should not come in contact with surgical or obstetrical cases.

The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms confirmed by bacteriological examination of the discharges.

2. *Isolation.* Strict isolation should be enforced during the period of communicability, particularly in hospitals.

3. *Immunization.* None.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* Careful bedside disinfection of all dressings, instruments, utensils, etc., used in connection with or coming in contact with the patient.

6. *Terminal Disinfection.* Thorough cleaning followed by thorough disinfection.

Tetanus

Synonyms. Lockjaw, trismus.

Definition. Tetanus is an acute infection characterized by painful tonic spasms of the muscles, affecting first and chiefly those of the jaw and neck and secondly those of the trunk and limbs.

Geographical Distribution. There are endemic centers of tetanus in practically all parts of the world, from Iceland to the tropics. In the United States it is most frequent in the Atlantic States, especially in the valley of the Hudson River and on Long Island. In the tropics it is a much more severe and common disease, as the infecting organism thrives in a high temperature.

The frequency of the infection in the wounded on the Western Front in the Great War indicates the presence of the germ in the soil of Northern France and Belgium.

Predisposing Conditions. Males are more susceptible and also more exposed than females, and robust individuals seem more receptive than the weak. An impaired nervous system predisposes to the infection. Tetanus is more prevalent in the hotter months as compared with the colder ones. Formerly the great number of infections on the Fourth of July partly accounted for this.

Infectious Agent. *Bacillus tetani.*

Source of Infection. Animal manure, and soil fertilized with animal manure, and, rarely, the discharges from wounds.

Dissemination. Tetanus is transmitted by inoculation or by wound infection. The natural habitat of the tetanus bacillus is the intestinal tract of herbivera, especially horses. The spores ingested with the food are unaffected by gastric digestion, and in the small intestines develop undei the anerobic conditions, food supply and favorable temperatures there prevailing. They pass with the feces and pollute the soil

The bacillus occurs in manure and in garden earth and street dust contaminated by the former; also in the dust of houses, hospitals, barracks, etc., in hay dust, in the mortar of old masonry, in putrefying fluids, and on splinters, nails, etc., lying on contaminated ground. Due to the great resistance of tetanus spores, they are blown about in dust and disseminated in dirt and manure.

Before antitoxins, vaccine viruses, and bacterial vaccines were controlled by Federal inspection occasional infections occurred through this means. Tetanus has been caused by the hypodermic injection, as a hemostatic, of gelatine containing tetanus spores.

There is more or less contamination by tetanus of the soil of all regions inhabited by man and domestic animals. The bacilli do not multiply in the soil, which only acts as a vehicle. Most infections are received more or less directly from the soil.

Musca domestica is credited with spreading tetanus spores over limited areas.

Portal of Entry. Traumatism, gross or microscopic, is necessary for the entrance of the germs of tetanus. Punctured, lacerated, and contused wounds, such as those produced by firearms, are much more susceptible to tetanus than in cised wounds or superficial abrasions, as they afford anerobic conditions for the development of the spores. Thousands of cases have followed blank cartridge wounds received on the Fourth of July. The spores are probably on the skin, and are carried into the tissues by the paper and powder of the blank cartridge. Wounds of the hands, which are apt to be contaminated with dirt, are especially dangerous.

The character of the wound is more important than its size. The infection may enter through wounds from small splinters, pin scratches, insect bites, vaccinations, wounds made by the hypodermic needle, etc. In the so-called idiopathic form the wound is either microscopic or located possibly in the pharynx or intestines.

There is a possibility that spores may be inhaled and enter through inflamed membranes or small wounds in the nose.

When proper antiseptic and aseptic precautions are not observed, infection at the umbilicus in the newborn and of women after childbirth, through the lacerated genital passages, is not uncommon. This is especially so among the filthy natives of the tropics and among the poor whites and Negroes of the Southern states.

Incubation Period. Six to fourteen days, usually nine.

Period of Communicability. Patient not infectious except in rare instances, where wound discharges are infectious.

Prophylaxis. GENERAL. 1. Supervision of the practice of obstetrics.

2. Educational propaganda such as "safety first" campaign, and "safe and sane" Fourth of July campaign.

3. Prophylactic use of tetanus antitoxin when wounds have been acquired in regions where the soil is known to be heavily contaminated, and in all cases where the wounds are ragged or penetrating.

4. Removal of all foreign matter as early as possible from all wounds.

5. Supervision of biological products, especially sera and vaccines.

THE INFECTED INDIVIDUAL AND HIS ENVIRONMENT. 1. *Recognition of the Disease.* Clinical symptoms; may be confirmed bacteriologically.

2. *Isolation.* None.

3. *Immunization.* By antitoxin, single or repeated injection.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* None.

6. *Terminal Disinfection.* None.

All wounds, insignificant and serious, should be promptly and thoroughly cleansed. Lacerated and punctured wounds (such as those containing garden earth or street dust), from which there is reason to fear tetanus, should be freely opened and all foreign matter carefully removed. This must be done without delay, to prevent the generation of toxin. After opening and cleansing the wound it is well to cauterize it with the actual cautery, carbolic acid, 25 per cent or stronger, or strong formalin solution. It may be advisable to excise the wound totally or amputate the limb. All suspicious wounds should be kept open and freely drained, allowing free access of air, unless prophylactic doses of antitoxin have been given, as is now the case in military practice.

Strict asepsis must be observed in the cutting of the umbilical cord and the treatment of the navel.

In surgical and obstetrical practice infection by tetanus is prevented by sterilization of instruments, bandages, suture material, etc., in the autoclave at 120° C. for twenty minutes, or exposure to dry heat at 160° C. for one hour. Tetanus spores are not always destroyed by boiling.

The tetanus toxin must be destroyed or neutralized in the wound before it is carried along the nerve roots to the spinal cord and brain. This may be accomplished by dusting dry antitoxin in the wound or by irrigation with formalin solution.

Tetanus antitoxin is a reliable preventive. It must be given before the symptoms develop, as the toxin cannot be displaced or neutralized after it has combined with the motor nerve cells of the central nervous system. If this has occurred the antitoxin can only prevent further damage, but this is, nevertheless, worth while.

The prophylactic dose is 1500 units of antitoxin. As the antitoxin is eliminated from or destroyed in the body in from ten days to two weeks, the dose must be repeated at intervals as long as the danger lasts. Bacilli may persist in the tissues and develop after the antitoxin has been exhausted.

Fourth of July wounds, especially those from blank cartridges, should promptly receive prophylactic doses of antitoxin in addition to careful local treatment.

In vaccinations surgical asepsis should be used in the operation and after treatment. Unnecessary scabs and anaerobic wound conditions must be avoided. Only vaccine that has been biologically tested according to the United States statutes should be used. (Rosenau.)

Cleanliness of body and clothing decreases the chances of tetanus and other infections in those liable to wounds.

Military. The following is from "The Memorandum on Tetanus" issued by the British War Office Committee on the Study of Tetanus.

The prophylactic value of injections of anti-tetanic serum is beyond all question, but there is strong experimental evidence that in about ten days the immunity conferred by the primary injection is to a great extent lost.

It is, therefore, the general opinion that a second subcutaneous injection should be given in all cases of septic wounds, and in order to anticipate the total disappearance of the antitoxin from the body, the second injection should follow the first at an interval of seven days.

In case of long-continued septic wounds, particularly those caused by shell or bomb, third and fourth injections at seven-day intervals are recommended.

If it is necessary to give a second, then it is also necessary to give a third or a fourth or further prophylactic injections, as the passive immunity conferred by the antitetanic serum is of short duration.

It may be definitely stated that the danger of anaphylactic shock is negligible when prophylactic doses of 500 U. S. A. units contained in 3 cm. of horse serum are given subcutaneously, whatever the interval after the preceding injection.

The primary injection should consist of 500 U. S. A. units, and the second and following injections should be, for the present, of the same amount.

The primary injection is given, as a rule, at a dressing station or field ambulance as soon as the wounded soldier is removed from the firing line. The second and following injections will most frequently be given at home hospitals. The ordinary phial usually contains 1500 units of tetanus antitoxin. One-third of a phial should, therefore, be injected into each wounded man. There is no necessity to sterilize the syringes after each injection—the serum is aseptic, and, moreover, contains an antiseptic; it will be sufficient if a freshly sterilized needle is used for each case.

When operations are performed at the site of wounds, even if they are healed, a prophylactic injection of serum should invariably be given if the operation be performed more than seven days after the last injection. Cases have occurred in which the performance of simple operations have been followed by an attack of tetanus, although in many cases the primary wound had been healed several weeks before the operation.

The precautionary injection may consist of a single subcutaneous injection of the ordinary prophylactic dose of 500 units, given, when possible, two days before the operation.

It is better to give it two days before the operation, as it takes some forty-eight hours for the antitoxin to be fully absorbed after subcutaneous injection. Injected intramuscularly, the absorption is quicker,—said to be about twelve hours,—so that this method could be used if time is pressing.

Of course, a larger dose than 500 units may be injected if thought advisable.

The group of oxidizing antiseptics, such as hydrogen peroxide, potassium permanganate, chlorine water, and solution of iodine, are particularly unfavorable to the anaerobic growth of the tetanus bacillus. They have the power of rendering toxin non-toxic.

Gas Infection and Gas Gangrene

Gas infection was very common in the wounded in the recent war. Fortunately the infection can be controlled with much success if it be seen and treated early. Gas gangrene, on the contrary, is a result of progressively developed infection and is a most dangerous condition.

Geographical Distribution. It is practically unknown in Great Britain and is very rare in North America.

Predisposing Conditions. Contamination of punctured and lacerated wounds with soil; retention of extravasated blood; interference with circulation; presence of masses of devitalized tissue; fracture and comminution of long bones; blood-stained dressing or clothes left in touch with the wound.

Infectious Agents. *Bacillus aerogenes capsulatus,* called *Bacillus perfringens* by the French. Other gas-producing bacteria, including the bacillus of malignant edema, are also found.

Source of Infection. In Belgium and Northern France shell wounds almost invariably have a gas bacillus infection which during the first few days gives rise to a foul-smelling reddish-brown discharge. Smears from gas gangrene wounds, showing such discharge, contain chiefly the gas bacillus and streptococci.

Dissemination. *Bacillus aërogenes capsulatus* is very abundant in the soil of highly fertilized areas and wounds are infected by contamination with this soil.

Portal of Entry. Wounds in the skin, particularly the lacerated and contused wounds made by fragments of shell and bombs.

Incubation Period. By the tenth hour the anaerobic bacteria begin to multiply rapidly in wounds; by twelve hours they are the dominant growth. Clinically the same astonishingly rapid development is seen. Well-marked infection with formation of gas has been observed within five hours, and death from gas gangrene of an entire limb in sixteen hours.

Period of Communicability. As long as the infectious organisms are discharged from the wound.

Prophylaxis. Bacteriologic diagnosis in the early stage is most important. Soon the discoloration of the skin, blebs, and crepitation make the diagnosis positive, but crepitation often appears late rather than early. The paramount importance of the earliest possible treatment of all wounds is self-evident. Every hour counts against the patient.

It is necessary to remove all foreign bodies (clothing, etc.) in the wound, as they will keep up the anaerobic infection; the wounds cleared of dead tissue and treated, if possible, by the Carrel-Dakin method.

Late reports indicate that prophylaxis of gas gangrene by antitoxin is now possible, and this is one of the most important contributions to surgery as a result of the war. The antitoxin has been sent to the surgeons in the field, and its routine use will doubtless decrease the incidence of this deadly infection.

Glanders

Synonym. Farcy.

Definition. An acute or chronic, widespread, communicable disease of equine origin characterized by nodules (infectious granulomata) in the nose (glanders) and beneath the skin (farcy).

Geographical Distribution. Glanders occurs in all countries and at all seasons of the year.

Predisposing Conditions. The disease affects almost exclusively males and persons who come in contact with horses, mules, and asses (hostlers, coachmen, farmers, soldiers of the mounted service, veterinarians, and stock raisers).

Infectious Agent. *Bacillus mallei.*

Source of Infection. Discharges from open lesions of mucous membranes, or of the skin of human or equine cases of the disease (i.e., pus and mucus from the throat, nose, and bowel discharges from infected man and horse).

Dissemination. Contact with a case or with articles freshly soiled by discharges from a human or equine case. It is very fatal in both man and beast. It is rare in man, but when encountered it has usually been contracted from the horse. Transmission from man to man has been rarely observed. Washerwomen have contracted glanders from the soiled clothes of a patient. There have been a number of laboratory infections from cultures of *Bacillus mallei.*

Portal of Entry. The infection is usually through small, perhaps microscopic, lesions of the skin or mucous membranes or by horse bites, though it may occur through the intact mucosa of the nose and air passages, the conjunctiva, and very rarely the digestive tract.

Incubation Period. This is believed to be from three to five days.

Period of Communicability. Until bacilli disappear from discharges or until lesions have healed.

Immunity. Man has considerable natural immunity to glanders.

Prophylaxis. General. 1. The abolition of the common drinking-trough for horses.

2. Sanitary supervision of stables and blacksmith shops.

3. Semi-annual testing of all horses by specific reaction where the disease is common.

4. Testing of all horses offered for sale where the disease is common.

THE INFECTED INDIVIDUAL AND HIS ENVIRONMENT. 1. *Recognition of the Disease.* By specific biological reactions, such as the complement fixation test, the mallein test, the agglutination test, or by non-specific reactions, such as the Strauss reaction, if confirmed by culture, or by identification of *Bacillus mallei,* or by autopsy of doubtful cases.

2. *Isolation.* Human case at home or hospital; for infected horses destruction rather than isolation is advised.

3. *Immunization.* None of established value or generally accepted.

4. *Quarantine* of all horses in an infected stable until all have been tested by specific reaction, and the removal of infected horses and terminal disinfection of stable have been accomplished.

5. *Concurrent Disinfection.* Discharges from human and equine cases and articles soiled therewith.

6. *Terminal Disinfection.* Stables and contents where infected horses are found.

To prevent glanders in man the disease must be suppressed in horses. This is accomplished by early diagnosis, the isolation of suspected animals, the killing and cremation of infected ones, and the cleansing and disinfection of infected stables. The early diagnosis of glanders by the complement fixation test is the quickest and most satisfactory method. Mild and missed cases are very common, and are important factors in the dissemination of the disease, especially in the crowded parts of cities.

Cleanliness is imperative in the prophylaxis of glanders. The bacillus, while sporeless and easily destroyed by the usual physical and chemical germicides, is frequently imbedded in albuminous matter or in the dirt of stables, water troughs, harnesses, etc. Hence cleansing, as well as disinfection, is necessary. In the cleansing and disinfecting processes special attention should be paid to the stalls, harnesses, water troughs, bits, food containers, curry combs, sponges, and other objects exposed to the infection, which is eliminated mainly in the secretions from the mouth and nose.

Men who handle horses and mules should be instructed as to the danger from glanders. When working with infected horses rubber gloves should be worn and disinfection and strict personal cleanliness should be practiced. Great care should be taken to prevent any discharge from the mouth, nose, or sores of diseased animals from coming in contact with wounds or scratches on the bodies of attendants, or being blown in their faces.

Actinomycosis

Synonyms. Lumpy-jaw, big-jaw, wooden tongue.

Definition. A chronic, communicable disease of cattle and other lower animals, less frequently of man, characterized by the development in the infected tissues of granulomatous masses, followed by metastatic growths and secondary pyemic infection.

Geographical Distribution. The affection is more common in Germany than in England or North America.

Predisposing Conditions. It is three times as common in men as in women.

Infectious Agent. *Streptothrix actinomyces* or ray fungus.

Source of Infection. The nasal and bowel discharges, and the infected material from lesions in human and animal cases of the disease. Uncooked meat from infected animals may serve as a source of infection.

Dissemination. Actinomycosis occurs in cattle, horses, goats, pigs, and sheep. It is called "lumpy-jaw" in cattle, in which animal it is most frequently seen. In order that human beings may be infected, some irritating foreign body (cereal grain or splinter) must accompany the germ. It is assumed that the infecting microbe is generally introduced with food or drink infected with discharges or with articles freshly soiled with discharges from animal or human cases.

Portal of Entry. Usually minute wounds in the mucous membrane of the mouth, the tongue, or the tonsils; sometimes the primary focus is in a carious tooth or in the alveolar margin near an erupting tooth. The intestines may be primarily or secondarily infected. The lungs may be infected through aspiration of the fungus in dust, or secondarily, by extension from the neck.

Incubation Period. Unknown.

Period of Communicability. As long as open lesions remain, as proved by the presence of the infective agent on microscopic or cultural tests.

Prophylaxis. GENERAL. 1. Inspection of meat, with condemnation of carcasses or infected parts of carcasses of infected animals.

2. Destruction of known animal sources of infection.

THE INFECTED INDIVIDUAL AND HIS ENVIRONMENT. 1. *Recognition of the Disease.* Clinical symptoms, confirmed by microscopic examination of discharges from the lesions.

2. *Isolation.* None, provided the patient is under adequate medical supervision.

3. *Immunization.* None.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* Of discharges from lesions and articles soiled therewith.

6. *Terminal Disinfection.* Thorough cleaning.

Anthrax

Synonyms. Malignant pustule, woolsorters' disease, splenic fever, charbon.

Definition. An acute, communicable disease occurring in three forms, cutaneous (malignant pustule), respiratory, and alimentary. It is characterized by the development of a pustule and septicemia, and in animals, particularly sheep and cattle, by enlargement of the spleen.

Geographical Distribution. Anthrax has a world-wide distribution, but is more prevalent in Europe and Asia than in the Americas. There are endemic centers in Eastern and Central Germany, Hungary, Russia, particularly Siberia, France, China, India, and Brazil. In the United States small epidemics have occurred in Pennsylvania and Delaware.

Predisposing Conditions. Occupation is the most important factor: persons who come into direct contact with infected animals (hostlers, butchers, shepherds), and workers in factories who handle the hides of such animals are liable to the infection.

Infectious Agent. *Bacillus anthracis.*

Source of Infection. Hair, hides, flesh, and feces of infected animals.

Dissemination. Inoculation as by accidental wound or scratch, inhalation of spores of the bacillus, and ingestion of insufficiently cooked infected meat.

Anthrax infects cattle, sheep, and other herbivora, including horses. Laboratory animals, such as mice, guinea pigs, rabbits, and rats may be experimentally infected. Goats, hogs, dogs, cold-blooded animals and birds are less susceptible.

The spores may be transmitted by water, earthworms, snails, fleas, flies, and inoculated into the skin by the bite of the stable fly (*Stomoxys calcitrans*). It has been conveyed by catgut prepared from diseased animals.

In animals anthrax is sometimes conveyed by direct inoculation as by the bites and stings of insects, or by feeding on the carcasses of animals dead of the disease, the bones cutting the buccal mucous membrane, thus forming a portal of entry for the spores. The most usual method is by grazing in pastures infected by the spores.

Pasteur taught that earthworms brought the bacilli that had been propagated in the buried carcass of an infected animal to the surface and distributed them. Farms or fields may be infected for long periods of time in this manner. The bacilli probably quickly die and no spores form if the carcass is not opened or the blood spilt.

Portal of Entry. In the cutaneous form the germs usually enter the skin through slight abrasions or small wounds, especially of the hands, forearms, and face.

Anthrax of the lungs, woolsorters' disease, or rag-pickers' disease is due to the inhalation of spores by persons working with hides, horse hair, or other raw material from animals infected with anthrax.

The intestinal form is contracted through eating meat from an infected carcass which has been improperly cooked or by drinking milk from an infected cow.

Incubation Period. Within seven days, frequently one to three days.

Period of Communicability. During the febrile stage of the disease and until lesions have ceased discharging. Infected hair and hides may communicate the disease for many months after slaughter of the animal, and after curing of hide, fur, or hair, unless disinfected.

Immunity. Man is much less susceptible than the herbivora. A number of species of animals, including the white rat, have a high degree of immunity.

Prophylaxis. General. 1. Animals ill with a disease presumably anthrax should be placed immediately in the care of a veterinary surgeon. Proved animal cases of the disease should be killed promptly and the carcasses destroyed, preferably by fire.

2. Isolation of all animals affected with the disease.

3. Immunization of exposed animals under direction of Federal or State Department of Agriculture.

4. Post-mortem examinations should be made only by a veterinary surgeon or in the presence of one.

5. Milk from an infected animal should not be used during the febrile period.

6. Control and disinfection of effluents and trade wastes and

of areas of land polluted by such effluents and wastes from factories or premises, where spore-infected hide and hair products are known to have been worked up into manufactured articles.

7. A physician should be constantly employed by every company handling raw hides, or such companies should operate under the direct supervision of a medical representative of the health department.

8. Every employee handling raw hides, hair, or bristles who has an abrasion of the skin should immediately report to a physician.

9. Personal instruction should be given to all employees handling raw hides in regard to the necessity of personal cleanliness.

10. Tanneries and woolen mills should be provided with proper ventilating apparatus so that dust can be promptly removed.

11. Disinfection of hair, wool, and bristles of animals originating in known infected centers before they are used or assorted.

12. The sale of hide from an animal infected with anthrax should be prohibited. A violation of this regulation should be immediately reported to the State Commissioner of Agriculture, by telegram, stating time, place, and purchaser to whom the hide was sold. The report should also be sent to the person purchasing the hide. Carcasses should be disposed of under the State Department of Agriculture. The inspection and disinfection of imported hides are under the supervision of the United States Bureau of Animal Industry. In the event that infection is introduced the State agricultural authorities have jurisdiction over infected animals and local or State health authorities have jurisdiction over infected persons.

THE INFECTED INDIVIDUAL AND HIS ENVIRONMENT. 1. *Recognition of the Disease.* Clinical symptoms, confirmed by bacteriological examination.

2. *Isolation* of the infected individual until the lesions have healed.

3. *Immunization.* None.

4. *Quarantine.* None.

5. *Concurrent disinfection* of the discharges from lesions and articles soiled therewith.

6. *Terminal Disinfection.* Thorough cleaning.

In large slaughter-houses infected carcasses are subjected to prolonged exposure to steam under pressure. Raw material which is liable to be infected with anthrax, such as hides, horse hair, etc., should be disinfected. Hides may be soaked in a solution of 1 to 2 per cent formic acid and .02 per cent bichloride of mercury. The hide returns to a condition resembling its raw state and the bichloride kills the anthrax spores.

Rubber gloves should be worn when making autopsies on animals dead of anthrax.

Rabies

Synonyms. Hydrophobia, lyssa.

Definition. An acute, specific disease of warm-blooded animals, characterized by tonic and clonic spasms of larynx, pharynx, respiratory and other muscles and by an almost invariably fatal termination.

Geographical Distribution. Rabies is known in every part of the world except Australia. It is common in Russia and France and occurs more often than is generally supposed in the United States. It is relatively rare in Germany, and has disappeared from England, the Scandinavian countries, and Switzerland, due to muzzling the dogs.

Predisposing Conditions. Children are more frequently infected because more exposed. The onset of symptoms is more rapid following infections of wounds about the face and head, then in order of frequency the hands and the other parts of the body. This relative order is due largely to the fact that the face, head, and hands are usually uncovered while the rest of the body is clothed, and the saliva is wiped from the teeth of the biting animal and little or none enters the wound. Sheep and long-haired dogs are protected in a similar manner. It also depends somewhat on the nerve supply of the parts. Punctured wounds are the most dangerous. The death rate of those bitten by rabid wolves is highest; then in order of decreasing severity come the cat, the dog, and other animals.

The prevalence of the disease is greatest from April to September, because more dogs run loose at this season. Contrary to former teaching, exposure to cold seems to increase the virulence of the virus. Fatigue and over-indulgence in alcohol predispose to the infection.

Infectious Agent. Unknown, possibly *Pasteuria negri* (Noguchi).

Source of Infection. Saliva of infected animals, chiefly dogs.

Dissemination. Ninety per cent of the cases of hydrophobia are caused by the bites of rabid dogs. Wild animals of the dog family and skunks sometimes transmit the disease to man. Every mammalian is susceptible to rabies, but it is perpetuated in civilized communities almost exclusively by the domestic dog. Among wild animals it occurs in wolves, jackals, foxes, and hyenas. Rabies is comparatively rare in cats, goats, sheep, and cattle, and still less frequently seen in horses and hogs.

Hydrophobia is usually communicated through a wound produced by biting, but as the virus is contained in the saliva it may be conveyed by licking if there are open wounds or fissures in the skin. The infection may be received through autopsy accidents or other openings in the integument, such as scratches made by animals.

Portal of Entry. The virus must be inoculated into the tissues. It is innocuous when swallowed.

Incubation Period. This is longer and more variable than in any other acute disease. It varies from fourteen days to a year or more. In man the average is about forty days. In bites upon the face the incubation period is short.

Period of Communicability. For fifteen days in the dog (not known in man) before the onset of clinical symptoms and throughout the clinical course of the disease. The virus remains in the tissues after death as it resists putrefaction.

Immunity. There must be considerable natural immunity to rabies. Probably about 10 to 15 per cent of people bitten by rabid animals, and not receiving the Pasteur treatment, develop the disease. The Pasteur treatment produces active immunity in man in about fifteen days. As this is much shorter than the incubation period, prompt treatment will generally—though not always—prevent the attack, especially if the bite is upon the face.

The immunity lasts for at least several years. Its nature is not definitely known. It is not an antitoxin. The blood contains immune bodies twenty days after the last injection. The immunity conferred by the treatment is not absolute, as some infected persons die after its administration.

Prophylaxis. GENERAL. 1. Muzzling of dogs when on public streets, or in places to which the public have access.

2. Detention and examination of dogs suspected of having rabies.

3. Immediate antirabic treatment of people bitten by dogs or by other animals suspected or known to have rabies, unless the animal is proved not to be rabid by subsequent observation or by microscopic examination of the brain and cord.

THE INFECTED INDIVIDUAL AND HIS ENVIRONMENT. 1. *Recognition of the Disease.* Clinical symptoms, confirmed by the presence of Negri bodies in the brain of the infected animal, or by animal inoculations with material from the brain of such infected animal.

2. *Isolation.* None if the patient is under adequate medi-

cal supervision, and the immediate attendants are warned of the possibility of inoculation by human virus.

3. *Immunization.* Preventive vaccination (Pasteur treatment) after exposure to infection by inoculation.

4. *Quarantine.* None.

5. *Concurrent disinfection* of saliva and articles soiled therewith.

6. *Terminal Disinfection.* Thorough cleaning.

Chapter VI

DISEASES SPREAD BY INFECTED ANIMAL FOODS

Malta Fever

Synonyms. Febris melitensis, febris undulans, Mediterranean fever, Gibraltar fever, rock fever, Neapolitan fever, Cyprus fever, febris sudoralis, septicemia melitensis.

Definition. A chronic, rarely acute, septicemic condition characterized by many undulatory febrile relapses, severe sweats, rheumatic or neuralgic pains, splenic tumor, and constipation.

Geographical Distribution. The disease prevails in the basin of the Mediterranean, especially in Malta. The coasts and islands of Italy, France, Greece, and other Mediterranean countries have endemic areas. It was formerly very common at Gibraltar. Malta fever also exists in India, China, the Philippines, North, East, and South Africa, the West Indies, Venezuela, Brazil, and in the goat-raising section of the Rio Grande Valley in Texas.

Predisposing Conditions. Those associated with goats, such as goat-herders, and persons drinking goats' milk or goats'-milk products such as cheese are predisposed to the infection. It is primarily a disease of warm countries, but isolated cases are reported from many parts of the temperate zones. It occurs all through the year, but is more common in the warm weather in the Mediterranean littoral.

Infectious Agent. *Micrococcus melitensis.*

Source of Infection. The milk of infected goats is the usual source of infection. The blood and urine of infected persons contain the bacilli, and they have been found in the vaginal discharges of infected women.

Dissemination. The disease is spread by the milk of infected goats and by butter and cheese made from such milk. There is a possibility that sexual intercourse may be a factor in transmission. Dust mixed with dried urine has caused infection.

Its dissemination among goats is by contaminated food and possibly by drinking human and animal urine when deprived of salt. Goats are not only susceptible to the disease, but act as carriers and discharge the coccus in the milk for a long time.

Human carriers certainly exist. There have been several laboratory infections. As the cocci are present in the peripheral circulation it is reasonable to suppose that a biting fly, louse, or mosquito might transfer the infection by going directly from one animal to another. This mode of transmission has not been demonstrated experimentally. The various modes of contact infection play a minor rôle and infection among the friends and attendants of patients is rare.

Portal of Entry. By the stomach (usual), by contaminated dust reaching the lungs, by subcutaneous injection, and possibly in rare instances through the genito-urinary tract by sexual intercourse.

Incubation Period. From ten to fifteen days. Laboratory infections have developed in six days.

Period of Communicability. As long as the cocci remain in the excretions and blood of human patients or in the excretions and milk of infected goats.

Immunity. It is generally stated that one attack usually confers immunity, but this is open to some question.

Prophylaxis. General. 1. Elimination of the disease in the goats by killing the infected ones.

2. Boiling of goats' milk.

The Infected Individual and His Environment. 1. *Recog-*

nition of the Disease. Clinical symptoms, confirmed by agglutination, complement fixation, and blood culture tests.

2. *Isolation.* In fly-proof room, preferably under hospital conditions. Convalescents should not be released from observation until the micrococcus has disappeared from the urine.

3. *Immunization.* None.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* Disinfection of all bowel and urinary discharges and articles soiled with them.

6. *Terminal Disinfection.* Cleaning.

Foot-and-Mouth Disease

Synonyms. Aphthous fever, epizoötic catarrh, eczema contagiosa, epidemic stomatitis.

Definition. An acute and highly communicable disease met with chiefly in cattle, sheep, and pigs, but occasionally attacking man. In the cloven-footed animals it is characterized by an eruption of vesicles on the mucous membrane of the mouth and on the skin between the toes and above the hoofs; sometimes on the udders or other parts of the body. In man the symptoms are: fever, digestive troubles, and vesicular eruption on the lips, the buccal, and the pharyngeal mucous membranes.

Geographical Distribution. The disease is prevalent in Europe, especially in Russia, also in South America, Asia, and Africa. Widespread epizoötics occur, particularly in the warm season. There have been six outbreaks in the United States, the last one in 1914.

Predisposing Conditions. The consumption of raw milk during the prevalence of the disease is the chief predisposing factor.

Infectious Agent. An ultramicroscopic, filterable virus.

Source of Infection. The virus is contained in the milk, saliva, tears, the serum of the vesicles, and various other secretions and excretions of the infected animals. It is also in the blood until the appearance of the eruption, when it disappears.

Dissemination. The disease is most often contracted by young children through drinking raw milk. In persons coming into contact with infected cattle, pigs, sheep, or goats, the transmission may be direct. The infection may be transmitted to man through milk products such as buttermilk, butter, cheese, and whey from animals suffering with foot and mouth disease.

Portal of Entry. The mucous membrane of the mouth. It is doubtful whether the disease can be transmitted to man by cutaneous or subcutaneous inoculation, though it is probable that the infection may be communicated if the virus enters the blood directly through wounds of any kind. (Rosenau.)

Incubation Period. This is variable; usually from two to six days or longer, occasionally as long as fifteen to eighteen days.

Period of Communicability. During the continuance of the virus in the secretions and excretions of the infected animal.

Immunity. An attack confers no definite immunity.

Prophylaxis. The disease should be kept out of countries where it does not prevail by a cattle quarantine. The infected herds should be isolated, the sick animals killed and buried, and the stables disinfected. Prophylaxis in man consists of care in the selection of animals from which milk is taken or by pasteurization of the milk during the prevalence of foot-and-mouth disease.

Vaccine virus has been known to contain the virus of foot-and-mouth disease, but no instance of the transmission of the disease by this mode has been recorded. It is doubtful if it is possible to infect man by the cutaneous inoculation used in vaccination. There is nothing to fear from this source, as the vaccine virus is subjected to special tests by the Federal authorities before being placed on the market.

As the milk is infected frequently from the hands of persons who examine milk or come in contact with diseased animals, the personal cleanliness of such persons should be assured.

Tuberculosis (Other than Pulmonary)

Infectious Agent. *Bacillus tuberculosis* (human and bovine).

Source of Infection. Discharges from mouth, nose, bowels, and genito-urinary tract of infected humans; articles freshly soiled with such discharges; milk from tuberculous cattle; rarely the discharging lesion of bones, joints, and lymph nodes.

Dissemination. By direct contact with infected persons, by contaminated food, and possibly by contact with articles freshly soiled with the discharges of infected persons. Infection may occur before birth (congenital tuberculosis, or intrauterine infection). A majority, however, are infected after birth (extrauterine infection) either from some other tuberculous human being (directly or indirectly), or from tuberculous cattle.

Portals of Entry. The bacilli enter the body most frequently through the digestive tract and the respiratory apparatus, but the spread in each case, from the infection atrium to other parts of the body, occurs through the lymph paths (lymphogenous tuberculosis). A few bacilli may enter the blood and reach distant organs (hematogenous infection). In some cases, large numbers break through a vein into the blood and cause a general miliary tuberculosis. Local wound infections also occur.

Incubation Period. Unknown.

Period of Communicability. Until lesions are healed.

Immunity. See "Tuberculosis (Pulmonary)."

Prophylaxis. General Measures. 1. Pasteurization of milk and inspection of meats.

2. Eradication of tuberculous cows from milch herds used in supplying raw milk.

3. Patients with open lesions should be prohibited from handling foods which are consumed raw.

The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms confirmed by bacteriological and serological examinations.

2. *Isolation.* None.

3. *Immunization.* None.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* Discharges and articles freshly soiled with them.

6. *Terminal Disinfection.* Cleaning.

Trichiniasis

Synonym. Trichinosis.

Definition. A group of phenomena produced by the *Trichinella spiralis,* commonly known as trichina.

Geographical Distribution. The disease is most common in North Germany, where raw ham and sausages are freely eaten. In South Germany, France, and England cases are rare. Stiles estimates that more than a thousand small outbreaks have occurred in the United States and sporadic cases are not uncommon.

Predisposing Conditions. The incidence of the disease in different countries depends upon the modes of preparation of pork in vogue. Salting and smoking the flesh is not always sufficient to kill the parasites. The eating of raw and imperfectly cooked pork predisposes to trichinaisis.

Infectious Agent. *Trichinella spiralis,* formerly *Trichina* *spiralis,* a round worm which passes its entire life cycle in man, rat, or hog.

Source of Infection. Uncooked or insufficiently cooked meat of infected hogs.

Dissemination. Consumption of raw or undercooked infected pork or the products of such pork.

Portal of Entry. The gastro-intestinal tract.

Incubation Period. Variable; usually about one week.

Period of Communicability. Disease is not transmitted by human host.

Immunity. None.

Prophylaxis. General Measures. 1. Inspection of pork products for the detection of trichiniasis.

2. Thorough cooking of all pork products at a temperature of 160° F. or over.

The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms, confirmed by microscopical examination of muscle tissue containing trichinæ.

2. *Isolation.* None.

3. *Immunization.* None.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* Sanitary disposal of the feces of the patient.

6. *Terminal Disinfection.* None.

Taeniasis (Intestinal)

Synonym. Tapeworms.

Definition. Infestation with certain genera of cestodes or flat worms.

Tænia solium (*Pork or Measly Tapeworm*). Not common in North America; most frequently met with in Europe and Asia. It passes the larval stage of its life history in the flesh of hogs, which become infested by eating human feces or from food and drink containing them. The encysted larvæ are known as bladder worms or *Cysticercus cellulosæ,* and are commonly called pork measles. Man eats the infested pork containing these larvæ, which develop into adult tapeworms in the intestines.

Tænia saginata or Mediocanellata (*Unarmed, Fat, or Beef Tapeworm*). Found throughout the world; rather common in North America. The larval stage of the life of the parasite is passed in the flesh of cattle. The larva embedded in the beef is known as *Cysticercus bovis.* Cattle are infested by eggs passed in human feces, which contaminate their food or water. The Cysticercus is found most frequently in the tongue and muscles of mastication. Man becomes infested by eating raw or underdone beef containing the larvæ, which develop into adult tapeworms in the intestinal tract.

Dibothriocephalus latus (*Fish Tapeworm*). Found wherever fresh fish forms a large part of the diet, especially in certain districts bordering on the Baltic Sea, in parts of Switzerland, and in Japan. The cysticercus is found in the muscles and organs of various fresh-water fish, particularly pike, perch, and several members of the salmon family, and grow into the adult worm when eaten by man. Fish become infested through the pollution of the streams with sewage containing the eggs of the parasite.

Prophylaxis. All tapeworm segments should be burned, not thrown into water-closets or on the ground; all meat should be carefully inspected at the abattoirs; meat should be cooked sufficiently to kill the parasites.

In prevention the sanitary disposal of feces, especially in rural districts where hogs and cattle are kept, must be considered. The flesh of hogs having a light infection may be cooked and eaten; the carcasses of those heavily infected should be destroyed. The *Cysticercus bovis* dies in three weeks after killing, hence beef that has been preserved twenty-one days may be regarded as safe. Cold storage is not so effective in destroying the *Cysticercus cellulosæ,* for it has been found alive after twenty-nine days.

The prevention of fish tapeworm consists in the proper cooking of fish, and the sanitary disposal of feces, so as to prevent the contamination of fresh-water streams.

Chapter VII

MISCELLANEOUS

Smallpox

Synonym. Variola.

Definition. An acute, highly communicable disease characterized by its sudden onset, a typical fever curve, and a cutaneous eruption that passes through the stages of papule, vesicle, pustule, and scab.

Historical Notes. The authentic history of smallpox is very ancient. It has existed from the earliest antiquity in Africa, India, China, and other Oriental countries. Prophylactic inoculation was used against it in China and India twelve centuries before the Christian Era. The "pesta magna" described by Galen was probably smallpox. It was very prevalent in the sixth century and during the Crusades spread throughout Europe. Its introduction into Mexico by the Spanish troops under Cortez was followed by one of the greatest epidemics recorded in history. It was brought to the American Colonies from Europe in 1649 and gained its first foothold in Boston. The last great epidemic in the United States was in 1901-1904, when the disease was introduced by the soldiers of the American Army of Occupation returning from Cuba.

The first accurate account was given by Rhazes, an Arabian physician who flourished in the ninth century. In the seventeenth century Sydenham differentiated smallpox from measles. Inoculation was introduced into Europe by Lady

Mary Montagu in 1718. Jenner discovered vaccination in 1796.

Geographical Distribution. No part of the world can be said to be exempt from epidemic outbreaks of smallpox. It is constantly prevalent in many parts of Africa, India, China, and South America. From time to time great epidemics or pandemics carry off thousands of the susceptible population of unprotected regions who have been born since the last visitation.

Predisposing Conditions. Smallpox is uninfluenced by age, sex, climate, soil, sanitary conditions, or position in life. The puerperium seems to increase liability to the infection. The fetus is sometimes affected *in utero.* Children born of mothers suffering from smallpox are usually protected by immediate successful vaccination.

It is especially severe among the dark races, particularly the Negro. If the contagion is once introduced among a susceptible population it rages alike in the palace and in the hovel. The susceptibility of a community depends upon the number of immunes protected by previous attacks or by successful vaccination.

Infectious Agent. An unknown filterable virus, possibly an ultramicroscopic protozoön. It passes through ordinary filters, but not through colloid filters.

Source of Infection. Lesions of the skin and mucous membranes of infected persons.

Dissemination. By direct personal contact; by articles soiled with discharges from lesions. The virus may be present in all body discharges, including feces and urine. It may be carried by flies or other insects.

It is assumed that it is air-borne, but this mode of infection has been greatly overestimated. It does occur, but within a very limited radius, and is never carried any considerable distance by air currents or by the wind. There is no danger in living near a properly managed and well-screened smallpox hospital. Surreptitious visiting and possibly flies and other insects may well account for smallpox cases in the neighborhood of hospitals.

More or less direct contact is the usual method of spreading the disease, though fomites or recently infected articles such as clothing, bedding, towels, handkerchiefs, books, letters, toys, pencils, dishes, silverware, in fact anything that comes in contact with a patient may harbor the virus and transmit the disease for short or considerable periods of time. Cadavers of variola victims are dangerous.

Portal of Entry. It is presumed that the virus enters the system through the respiratory mucous membrane. There is the possibility that infection occurs through the digestive tract and through the skin.

Incubation Period. Twelve to fourteen days, rarely as long as twenty-one days.

Period of Communicability. From earliest prodromal symptoms to disappearance of all scabs and crusts.

Immunity. There appears to be little or no natural immunity to the disease. An attack may not protect for life. There are authentic cases of a second and reputed instances of a third attack.

Prophylaxis. GENERAL. General vaccination in infancy, revaccination of children on entering school, and of entire population when the disease is prevalent.

Adjustment of the time of vaccination of infants to avoid teething and other mild indispositions, the time of vaccination of children at the runabout age and older with preference for the cooler months of the year, and the manner of vaccination with preference for the single puncture or small area scratch method through the droplet of virus are important to observe in order to avoid possible complications and subsequent infections at the site of vaccination. Vaccination before the age of six months is particularly desirable.

THE INFECTED INDIVIDUAL AND HIS ENVIRONMENT. 1. *Recog-*

nition of the Disease. Clinical symptoms. Tests for immunity may prove useful.

2. *Isolation.* Hospital isolation in screened wards, free from vermin, until period of infectivity is over.

3. *Immunization.* Vaccination.

4. *Quarantine.* Segregation of all exposed persons for twenty-one days from date of last exposure, or until protected by vaccination.

5. Concurrent disinfection of all discharges and of all articles used by or in connection with the patient.

6. *Terminal Disinfection.* Thorough cleaning and disinfection of premises.

Disinfection and isolation are auxiliary procedures in the prophylaxis of smallpox. The spread of the disease is prevented by general vaccination.

If bedside disinfection and medical asepsis are practiced smallpox can be treated in a special ward of a hospital for communicable diseases. Special hospitals in isolated places are unnecessary. It should not be treated at home unless skillful nurses and attendants are available.

Smallpox patients should not be released from isolation until desquamation has entirely ceased. Warm soap baths and lubrication of the skin with a bland vegetable oil or vaseline materially assists the removal of the scales. The head should be shampooed. All folds and crevices of the skin, including the spaces between the fingers and toes, should be carefully inspected. A bichloride of mercury bath, 1-5000, should be taken before leaving the sick-room or hospital ward.

Chickenpox

Synonym. Varicella.

Definition. An acute communicable disease characterized by an exanthem of vesicles with pearly contents and by little or no constitutional disturbance.

Historical Note. The disease was first differentiated from smallpox by a Neapolitan savant in 1553.

Predisposing Conditions. It chiefly affects children; the majority of cases occur between the second and the sixth year. It is occasionally observed in the adult.

Infectious Agent. Unknown.

Source of Infection. The infectious agent is presumably present in the lesions of the skin and of the mucous membranes. The latter appear early and rupture as soon as they appear, rendering the disease communicable at early period, that is before the exanthem is in evidence.

Dissemination. The fact that it occurs in epidemics, especially in institutions such as orphan asylums and in schools, leads to the assumption that it is spread by direct and indirect contact. Chickenpox is very readily communicable, but epidemics are seldom widespread. It never entirely dies out in large cities.

Portal of Entry. Unknown.

Incubation Period. Two to three weeks.

Period of Communicability. Until the primary scabs have disappeared from the mucous membranes and the skin.

Immunity. Most children have but one attack; second and third attacks are, however, occasionally observed.

Prophylaxis. General. Cases of chickenpox should be reported, if for no other reason than that it is frequently mistaken for smallpox.

The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms. The differential diagnosis of this disease from smallpox is important, especially in patients over fifteen years of age.

2. *Isolation.* Exclusion of the patient from school, and prevention of contact with non-immune persons.

3. *Immunization.* None.

4. *Quarantine.* None.

5. *Concurrent disinfection* of articles soiled by discharges from lesions.

6. *Terminal Disinfection.* Thorough cleaning.

Leprosy

Synonym. Lepra.

Definition. A chronic infection characterized by tubercular nodules in the skin and mucous membranes and by changes in the nerves.

Historical Notes. Leprosy prevailed in Egypt forty centuries before Christ. It is referred to many times in the Old Testament, but the Biblical writers embraced many forms of skin diseases under the term leprosy. It has been endemic in the Orient from time immemorial. The medical writers of classical antiquity described the disease. Its existence in the Americas before the arrival of Europeans is a matter of dispute. The prevalence of leprosy in Europe during the Middle Ages is a sad commentary on the sanitary conditions of those times, and its decline during the sixteenth century is an index of the improvements in sanitation and standards of living that marked that century.

Geographical Distribution. In Europe leprosy is found in parts of Russia, Finland, Sweden, Norway, Iceland, in some of the provinces of Portugal and Spain, and in the Balkans. There are many cases in India, Indo-China, China, and Japan. It prevails to some extent among the Filipinos. In Australia it occurs principally among the Chinese. It is prevalent in the islands of the Pacific, especially the Sandwich Islands. Mexico, Central and South America have many lepers. The West Indian islands have endemic foci. Sporadic cases have appeared in most American cities. It was brought to the Pacific Coast by the Chinese and to Minnesota, Wisconsin, Iowa, and Illinois by Scandinavian immigrants. There is an endemic center on the Gulf Coast in Louisiana and Florida. Some cases occur in the Maritime Provinces of Canada. It is found in many parts of Africa and is apparently on the increase in South Africa.

Predisposing Conditions. Human beings are only slightly susceptible to leprosy, but no race is immune. Its greater prevalence among Asiatics and Africans is probably due to their filthy modes of life. The infection is uninfluenced by sex or climate. It is most frequent between the ages of twenty and forty, and is rare in childhood. It is more common in the poorer than in the upper and middle classes.

Infectious Agent. *Bacillus lepræ.*

Source of Infection. The discharges from leprous lesions. The bacillus has been found in the urine and milk of patients.

Dissemination. By close, intimate, and prolonged contact with infected individuals. Flies and other insects *may* be mechanical carriers.

The degree of contagiosity of leprosy is very low, and there is the possibility of an intermediate change in the virus. Close relationship, as in families, or sleepng in the same bed, or sexual intercourse, especially under conditions of personal and domestic uncleanliness and overcrowding, are largely responsible for its dissemination. It is undoubtedly an infection that in all cases passes rather directly from person to person. The greatest danger is from discharging lesions of the skin or mucous membranes. The anesthetic form is slightly if at all contagious.

Conclusive evidence is lacking that leprosy is hereditary. Some children are infected in early childhood by intimate contact with leprous parents.

The leprosy bacillus has been found in the intestinal canal of a number of insects, including mosquitoes, flies, and bedbugs, it is exceedingly improbable but that the disease is transmitted by insects. The evidence is entirely presumptive, and based upon analogy. No instance of this mode of infection is known.

The theory of Jonathan Hutchinson that leprosy is due to eating fish is entirely discredited.

Portal of Entry. Just how the virus enters the body is in dispute. Possibly the bacillus gains admission through wounds in the skin or the mucous membranes of the nose and throat or through the digestive tract or by all of these modes. It is more than likely that infection occurs through the genital organs during coitus.

Incubation Period. This is very prolonged and undetermined. From three to twenty years have been suggested.

Period of Communicability. Infectivity exists throughout the duration of the disease. Where good standards of personal hygiene prevail the disease is but slightly communicable.

Prophylaxis. GENERAL MEASURES. 1. Lack of accurate information as to the determining factors in the spread and communication of leprosy makes any but general advice in matters of personal hygiene of no value.

2. As a temporary expedient, lepers may be properly cared for in local hospitals, or if conditions of the patient and his environment warrant, he may be allowed to remain on his own premises under suitable regulations.

THE INFECTED INDIVIDUAL AND HIS ENVIRONMENT. 1. *Recognition of the Disease.* Clinical symptoms, confirmed by bacteriological examination.

2. Isolation for life in a national leprosarium when this is possible.

3. *Immunization.* None.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* Discharges and articles soiled with discharges.

6. *Terminal Disinfection.* Thorough cleansing and disinfection of premises of patient.

Efforts to obtain a specific preventive or cure for leprosy have borne no satisfactory results. The results of the use of nastin and leprolin are not encouraging. Tuberculin does not materially influence the course of the disease, but seems to cause a local improvement of the leprous nodules. Favorable results have been reported from the use of the roentgen rays. The same principles of diet, cleanliness, and fresh air useful in tuberculosis give the best results in the prevention and treatment of leprosy.

All suspicious cases should be registered and all clear cases isolated.

The disease is seldom transmitted to the attending physicians, nurses, Sisters of Charity, and priests exposed in leper colonies.

In the light of our present knowledge the dissemination of leprosy can be prevented only by isolation, care of infected discharges, personal cleanliness, and sanitary surroundings.

Lepers must be segregated in settlements or asylums. Compulsory notification of every case of leprosy should be mandatory. Segregation is the most important procedure, and was probably an important factor in checking the disease in Europe in the sixteenth century. The leprosaria should be built and equipped similarly to modern tuberculosis hospitals. The small number of lepers in the United States should be cared for in a national leprosarium. As the dissemination of leprosy is so imperfectly understood and as segregation in the Sandwich Islands has not checked the disease, some contend that the value of this measure is overestimated. In countries such as the United States, where a relatively high degree of personal cleanliness is the rule, the danger that a leper of clean personal habits, who properly cares for the discharges from the lesions, will spread the disease is very small.

The Quarantine Regulations of the United States forbid the landing of an alien leper. If one reaches an American port he must be deported on the same vessel that brought him. An American citizen having leprosy cannot be refused admission, but on admission immediately becomes subject to the health laws of the State and the port of entry.

Epidemic Jaundice

Synonyms. Spirochætal jaundice, rat-bite disease, Weil's disease, infectious jaundice.

Definition. An acute, infectious inflammation of the gall-ducts with jaundice and an enlarged spleen.

Geographical Distribution. The Far East, especially Japan; the Levant; the Balkans; Central and Western Europe, North Africa. The infectious agent has been isolated from rats in North America, and it is possible that further studies will show the disease to be world-wide in its distribution.

Predisposing Conditions. Close association with rats and living or working in stagnant water or moist earth.

Infectious Agent. *Septospira ictero-hæmorrhagica.*

Source of Infection. The infected urine of rats is probably the source of the spirochæte in man, and the urine of patients is doubtless a secondary source. The infection in rats is chronic, the organism being excreted in the urine for long periods. In very rare cases in Japan the disease has occurred about six days after a rat-bite.

Dissemination. The disease is chiefly observed in wet mines and in imperfectly drained trenches infested with infected rats, who pollute the soil and water and the belongings of men with their urine. The spirochæte can live for a time in water. The disease ceases to spread or disappears when the mines are pumped dry or the trenches drained.

There is no evidence that mosquitoes, fleas, or lice are in any way concerned in the conveyance of the disease, and no cases have been observed in which the infection has appeared to pass direct from man to man.

Portal of Entry. Infection can be produced experimentally through the alimentary canal and through abrasions on the surface of the body and even through apparently healthy skin. The infection probably occurs under natural conditions through both of these channels. The Japanese miners are doubtless infected by working in the polluted water of the mines in their bare feet or in sandals.

Incubation Period. Between five and seven days.

Period of Communicability. In Japan, where the most careful observations have been made, the spirochæte is present in the urine during the first four weeks.

Prophylaxis. Wherever cases of epidemic jaundice have occurred the ground should be disinfected or drained as thoroughly as possible, and a special effort made to destroy the rats. The urine of patients should be disinfected for nine weeks from the date of onset of the disease. (Hurst.)

While the spirochæte etiology certainly holds for certain types of infectious jaundice, yet it must not be forgotten that many cases seem to be connected with *Bacillus paratyphoid B.* infections, such organisms having been isolated from blood and duodenal contents of patients with the disease. (Stitt.)

Trachoma

Synonym. Granular conjunctivitis, ophthalmia Ægyptiaca.

Definition. A communicable, inflammatory disease of the palpebral conjunctiva, which becomes thickened, vascular, and covered with granular elevations; the latter may ulcerate and cicatrize.

Geographical Distribution. Trachoma is exceedingly common in China and quite so in India, Japan, and South America. It is prevalent in North Africa, especially in Egypt, in South Africa, and southern Europe. The disease is much more common in the United States than is ordinarily supposed. It is more or less prevalent in the poorer sections of all the larger centers. Several States, especially Oklahoma, have foci that are a matter of grave concern to sanitarians.

Infectious Agent. Hæmoglobinophilic bacilli, including the so-called Koch-Weeks bacillus, are the chief agents, but they have not yet been proven to be the only causative organisms.

Source of Infection. Secretions and purulent discharges from the conjunctivæ and adnexed mucous membranes of infected persons.

Dissemination. By direct contact with infected persons and indirectly by contact with articles freshly soiled with the infective discharges of such persons. Roller towels, handkerchiefs, and soiled fingers are media of infection. Trachoma thrives best in unsanitary surroundings.

Portal of Entry. The conjunctiva.

Incubation Period. Undetermined.

Period of Communicability. During the persistence of lesions of the conjunctivæ and of the adnexed mucous membranes or of discharges from such lesions.

Immunity. When once established the disease is chronic, and permanent cures are doubtful.

Prophylaxis. The Infected Individual and His Environment. 1. *Recognition of the Disease.* Clinical symptoms. Bacteriological examination of the conjunctival secretions and lesions may be useful.

2. *Isolation.* Exclusion of the patient from general school classes.

3. *Immunization.* None.

4. *Quarantine.* All immigrants arriving at American ports are examined for trachoma by having their eyelids averted. Aliens found infected are deported and the steamship bringing them is liable to a fine of $100 for every case where it can be shown that the disease might have been detected at the port of departure.

5. *Concurrent disinfection* of discharges and articles soiled therewith.

6. *Terminal Disinfection.* None.

General Measures. 1. Search for cases by examination of school children, of immigrants, and among the families and associates of recognized cases. In addition, search for acute sectoring disease of conjunctivæ and adnexed mucous membranes, both among school children and in their families, and the treatment of such cases until cured.

2. Elimination of common towels and toilet articles from public places.

3. Education in the principles of personal cleanliness and the necessity of avoiding direct or indirect transference of body discharges.

4. Control of public dispensaries where communicable eye diseases are treated.

Tinea Favosa

Synonym. Favus.

Definition. A communicable affection of the skin characterized by the development of either discrete or confluent, small circular, cup-shaped, pale-yellow, friable crusts, usually perforated by hairs.

Predisposing Conditions. It is a disease confined almost exclusively to the lower classes, especially of Russians, Poles, Austrians, and Hungarians. It is more common in children than in adults.

Infectious Agent. *Achorion schœnleinii.*

Source of Infection. Lesions of skin, particularly on the scalp.

Dissemination. Direct contact with patient, and indirectly through toilet articles. It is not infrequently contracted from cats, dogs, and other lower animals.

Incubation Period. Unknown.

Period of Communicability. Until scalp and skin lesions are entirely healed.

Prophylaxis. General Measures. 1. Elimination of utensils common to all, such as hair brushes and combs.

2 Provision for adequate and intensive treatment and cure

of cases of favus at hospitals and dispensaries, to abbreviate the period of infectivity of the patients.

1. *Recognition of the Disease.* Clinical symptoms confirmed by microscopic examination of crusts.

2. *Isolation.* Exclusion of patient from school and from other public places until lesions are healed.

3. *Immunization.* None.

4. *Quarantine.* None.

5. *Concurrent Disinfection.* Toilet articles of patient.

6. *Terminal Disinfection.* None.

Tricophytosis

Synonyms. Tinea tricophytina, ringworm, dermatomycosis tricophytina.

Definition. A communicable disease of the skin and its appendages due to vegetable parasites of the order of molds. According to location several clinical varieties are recognized:

1. Ringworm of the non-hairy surfaces, tinea circinata, or ringworm of the body.

2. Ringworm of the scalp, tinea tonsurans.

3. Ringworm of the beard, barber's itch, tinea sycosis.

4. Ringworm of the genitocrural region, and occasionally of the axillæ, where the clinical manifestations of the disease are influenced by the abundance of warmth and moisture.

5. Ringworm of the nails, tinea unguium.

While the varieties of ringworm differ in their clinical manifestations all develop in similar ways. The essential difference between the different forms depends upon whether there is involvement of the hairs or not.

Predisposing Conditions. Ringworm of the non-hairy surfaces may occur at any age, but is much less common in adults than in children; the so-called eczema marginatum or ringworm of the thighs, however, is a disease of adult life.

Ringworm of the scalp is practically never seen in those past the age of fifteen. Some ill-defined impairment of the integument is apparently a predisposing factor in tinea sycosis. Sex *per se* has but little influence, but the more violent inflammatory forms are observed more frequently in males than in females, because the former are much more likely to come in contact with the lower animals from which these forms are contracted. Occupation, as affording special opportunity for infection, exerts some influence in its production; dairymen, hostlers, and all others whose employment brings them in with the lower animals, are particularly liable to the severe forms. School children and the inmates of orphan asylums or other institutions in which large numbers of children are collected are especially the subjects of ringworm. It has been demonstrated that inoculation with the parasite succeeds much more readily in those with alkaline sweat, acidity of this fluid apparently diminishing susceptibility.

The patient's general condition does not influence in any way his susceptibility to the infection, nor its course when once contracted. (Hartzell.)

Infectious Agents. There are three chief varieties of the fungi that cause ringworm: The *Tricophyton microsporon* or *Microsporon Audouini,* the *Tricophyton megalosporon endothrix,* and the *Tricophyton megalosporon ectorix.* Numerous subvarieties of each of these have been described, but the distinctions drawn are of little interest to the sanitarian.

Source of Infection. The lesions of the skin and its appendages.

Dissemination. All varieties of ringworm are more or less communicable, infection occurring through immediate contact or, what is much more frequent, through the intervention of various articles of clothing, such as hats, underwear, or articles of the toilet, such as towels, combs, brushes, etc., which frequently serve as carriers of the infecting organism. The disease is quite frequently contracted from some one of the lower animals, such as the horse, cow, cats, and dogs, this origin being especially common in those varieties exhibiting unusually severe inflammatory symptoms, or accompanied by suppuration with invasion of the deeper tissues, as in kerion and other forms of deep tricophytosis. It sometimes originates in barber shops, hairdressing establishments, and the so-called beauty parlors.

Period of Communicability. Until the lesions are completely healed.

Immunity. It has been observed that those who have had bovine tricophytosis seem to have acquired immunity for that affection and that a partial immunity has followed inoculation with cultures of certain of the tricophytons.

Prophylaxis. Adults and children must be taught to use their own brushes, combs, and towels, and not to wear the underclothing, hats, caps, etc., of others. Children with ringworm should not be allowed to attend school unless the lesions are properly dressed and covered with collodion. Some cities provide special schools for children with favus and ringworm of the scalp, where the pupils are treated. The medical inspection of schools and the careful medical supervision of institutions prevent the dissemination of the infection, as the cases are detected early. Barber shops, hairdressing shops, and beauty parlors must be compelled to obey the laws of hygiene and sanitation. Infected cats and dogs should be killed or excluded from the house until cured. Infected live stock should receive prompt veterinary attention.

TROPICAL DERMATOMYCOSES

Tinea Cruris

Tinea tropicalis, tinea inguinalis, tinea axillaris, eczema marginatum, dhobie itch. The name dhobie or washerman's itch has been given on account of associating it with the infection of the underclothing while being washed in the pools or streams along with the garments of those who have this skin disease. (Stitt.) This lacks scientific verification, but probably has some foundation of truth. The infection is familiar to nearly every one who has lived in tropical countries. It is caused by various species of Epidermophyton. This genus differs from Trichophyton in that it never invades the hair or hair follicles. The species which have been more frequently reported are *Epidermophyton cruris, E. perneti,* and *E. rubrum.*

Prophylaxis. This consists in personal cleanliness, the wearing of underclothing that has been laundered under sanitary conditions, and the use of a dusting powder, such as talcum powder, in the crotch and in the axillæ after the daily bath. The underclothing should be changed daily. The introduction of steam laundries in army posts and naval stations in the Philippines was followed by a decrease in dhobie itch.

Tinea Imbricata

Dermatomycosis chronica exfoliativa, herpes desquamans, Bowditch Islands ringworm, tokelau (Samoa). This ringworm is chiefly seen in islands of the South Pacific, the Malay Archipelago, and Southern China. The disease is extending into other parts of the tropical world, and many cases are now seen in Southern India, Ceylon, and the Philippines. Cases have been reported from various parts of tropical America. It spreads rapidly when introduced into a country with a high relative humidity and a fairly uniform temperature of between 80° and 90° F. It is not readily disseminated in a dry climate or one showing considerable variations of temperature. It is caused by two species of Endodermophyton, *E. concentricum* and *E. indicum.* (Castellani.)

Prophylaxis. Segregation has been recommended, but this is impracticable, in endemic centers, as the number of cases is frequently very great. Personal cleanliness, and the immediate and active treatment of any scaling spot, should be carefully practiced in the endemic countries. (Manson.) In tropical countries where the disease has not yet appeared medical officers and other physicians should be on the lookout, and if a case is detected the patient should be isolated and thoroughly treated before allowing him to associate with other patients or the general population.

Pinta

Mal de los pintos, tache endemique des Cordillières. The term pinta is applied to a group of closely allied dermatomycoses characterized by the presence of various colors, due to different species of fungi of the genera Aspergillus, Pencillium, Monilia, and Montoyella. The malady is practically limited to tropical America, especially Colombia, though it is also found quite commonly in Venezuela, Peru, Chili, the Central American States, and Mexico.

Prophylaxis. Personal cleanliness, the prompt treatment of all scaly spots, and the destruction of all old clothes that may be infected are the only practical measures.

Scabies

Synonym. Itch.

Definition. A communicable, animal parasitic disease characterized by a special lesion, the cuniculus or burrow, accompanied by intense itching with resultant secondary dermatitis from scratching.

Geographical Distribution. Scabies is encountered from the polar regions to the equator in both hemispheres. The most severe forms of the disease are found among the neglected lepers in Norway. It has apparently increased greatly in frequency in the United States in the past few years.

Predisposing Conditions. It is much more common in winter, and is chiefly seen among the poor and careless classes, but scabies is by no means a poor man's disease. It is frequently seen among people of careful habits and good surroundings. It is common among prostitutes. All ages are liable to the infestation. Crowding together in lodging houses, barracks, etc., and the use in common of clothing and bedding are predisposing factors.

Infectious Agent. The *Acarus scabei* or *Sarcoptes scabei*—the itch mite. The female alone burrows in the skin and produces the symptoms of the disease.

Source of Infection. The affected skin surfaces of infested persons.

Dissemination. Scabies is transmitted by intimate contact either with individuals or with infested articles. Its transmission is possible by such slight contact as shaking hands or the use of towels or other toilet articles, but this is not likely. It is usually contracted in the intimate contact of family life, from crowding together in lodging houses, barracks, etc., from bedding, or from infested clothing.

Portal of Entry. The impregnated female burrows into the epidermis, especially where it is thin, as the webs of the fingers and the penis.

Incubation Period. The impregnated female will bore its way into the epidermis within half an hour to an hour after being placed upon the surface.

Immunity. None.

Prophylaxis. This consists in following the precepts of personal hygiene in regard to cleanliness, the use of one's own clothing, bedding, and toilet articles. Overcrowding of barracks, dormitories, etc., must be avoided. The sanitary supervision of lodging houses and the establishment of municipal lodging houses as tending toward cleanliness and less intimate contact will have a favorable influence in decreasing the dissemination of scabies. As it is apparently spread among the better classes chiefly through hotels and cars, their proper sanitation is important. All children infested with scabies should be excluded from school. All members of an infested family should be treated until cured, otherwise reinfestations within the family circle will occur. All clothing, bedding, towels, etc., that come in contact with the body should be boiled each time they are washed.

Pediculosis

Synonyms. Lousiness, phthiriasis, morbus pedicularis, vagabond's disease.

Definition. An animal parasitic disease of the skin characterized by a multiform eruption chiefly of secondary character, due to scratching. Infestation with lice is of interest to the sanitarian chiefly because of the potential danger of the transmission of typhus, relapsing fever, and trench fever.

Geographical Distribution. The known world.

Predisposing Conditions. Lousiness is commonly associated with filth, poverty, vagabondage, general sordidness, overcrowding, and close personal contact. As the last two conditions unavoidably exist in times of war, especially in the trenches and near the front, the most cleanly and careful officers and men become infested.

Infectious Agents. Three varieties infest man:

(1) *Pediculus vestimentorum* or *Pediculus humanus, corporis,* which lives in the clothing. In civil life it is seen most commonly in the middle-aged and old, the most severe cases being seen in the aged poor; it is decidedly uncommon in children. Under military conditions it has no respect for age, race, or rank.

(2) *Pediculus humanus, capitis,* which lives in the hair of the scalp. It is seen much more frequently in children than in adults, and in the poor and badly cared-for than in the well-to-do and the cleanly. Women are more often affected than men, owing, probably, to their long hair. Apparently certain individuals, for unknown reasons, become infested more readily than others.

(3) *Phthirius pubis* or *Pediculus pubis*, which lives in the pubic and occasionally in the other short stiff hairs. For obvious reasons, this variety is, as a rule, only observed in the adult. Very infrequently it is found in the eyelashes of children. This is commonly known as the crab louse, so called from its form.

Dissemination. *Pediculus corporis* and its ovum are disseminated by infested clothing, bedding, etc., generally in conditions of overcrowding and squalor. The transference of *Pediculi capitis* requires intimate contact, and it is usually the result of the closest personal association, the interchange of hats, or the common use of brushes and combs. It is a source of annoyance and must be constantly watched for in the public schools. *Pediculus pubis* is commonly contracted during sexual intercourse, but may be contracted through infested clothing, bedding, toilet seats, etc.

Prophylaxis. The destruction of the body louse is described under "Military Sanitation." Coal oil, alone, or mixed with balsam of Peru, is the most effective paraciticide for *Pediculus capitis,* and mercurial ointment or bichloride of mercury 1-500, for *Pediculus pubis.*

In civil life improving the condition of the poor, the elimination of vagabondage, the teaching and observance of the rules of personal hygiene, and the medical inspection of schools are the most effective measures in checking the dissemination of the louse.

Frambœsia

Synonyms. Yaws, pian (French colonies), bubas (South America).

Definition. A specific, communicable disease characterized by an eruption of papules and papillomatous nodules.

Geographical Distribution. Yaws was first described as an affection existing early in the sixteenth century in the West Indies. It has been suggested that the disease was introduced into America by infected slaves from Africa, as epidemics occurred on the slave ships. The affection is essentially a tropical one. It is very prevalent in the African equatorial region, especially in the Congo Free State; it occurs less frequently in North Africa and in the Sudan. In Ceylon, Siam, the Malay Peninsula, the East Indies, and in the Philippines it is very common. Japan is free from the infection. It prevails extensively in the islands of the Pacific, particularly in Samoa. It is seen in Northern Australia. Yaws is a well-known disease in the West Indies and throughout tropical America.

Predisposing Conditions. Lack of knowledge and attention to personal hygiene such as exists among the natives of tropical countries is the strongest predisposing condition. Europeans are rarely infected. In endemic centers it is chiefly a disease of childhood, as many adults are immunized by attacks early in life.

Infectious Agent. *Treponema pertenue.*

Source of Infection. The secretions from yaws lesions.

Dissemination. While this disease is usually transferred by direct contact, it is transferred by indirect contact also, but not by sexual intercourse. Flies transfer the secretions from yaws lesions to abrasions or ulcers on the skin of healthy persons.

Portal of Entry. Any abrasion, such as a scratch, may serve as the portal of entry of the infection, which also frequently takes place through the medium of preëxisting ulcers, whatever their origin.

Incubation Period. From two to six weeks.

Period of Communicability. During the continuance of the lesions.

Immunity. An attack confers immunity. The susceptibility to the disease is general.

Prophylaxis. Theoretically cases of yaws should be segregated; this is not practicable. All abrasions and wounds in those hitherto unaffected should be properly protected by dressings. Yaws lesions should be dressed with antiseptic ointments to prevent the diffusion of the infecting organisms by contact or by flies. Care should be taken to prevent articles of clothing contaminated with yaws from acting as infecting agents. The huts and belongings of yaws cases should be thoroughly disinfected; notoriously infected huts should be burned, and yaws discharges should be prevented from polluting the bathing water.

Botulism

Synonyms. Sausage Poisoning (f. L. botulus, sausage).

Definition. A specific intoxication characterized by nausea, gastric pains, vomiting, difficulty in swallowing, visual disturbances, paralysis, and, in case of recovery, slow convalescence.

Geographical Distribution. In Europe, botulism has been most frequent in Germany; in America, California and the Central West have furnished a majority of the cases.

Predisposing Conditions. The eating of smoked, pickled or canned food such as sausage, ripe olives, beans and asparagus. The danger is probably greater from domestically canned food as the higher temperatures used in commercial canning processes are more certain to destroy the toxin.

E. O. Jordan states in "Food Poisoning":

"The following unusual set of factors must co-operate in order that botulism poisoning shall take place: (1) the presence of the bacilli in sufficient numbers in a suitable foodstuff; (2) the initial preparation of the food by a method that does not destroy the bacillus botulinus—inadequate smoking, too weak brine, or insufficient cooking; (3) the holding of the inadequately preserved food for a sufficient length of time under the right conditions of temperature and lack of oxygen; (4) the use of this food, in which conditions have conspired to favor the production of toxin by *Bacillus botulinus,* without final adequate cooking. It seems as reasonable to suppose that the infrequency with which these several factors coincide is responsible for the relative uncommonness as to suppose it due to the rarity of the specific bacillus."

Infectious Agent. *Bacillus botulinus.*

Source of Infection. Infected food. The bacillus does not grow in the body; the toxin is generated outside the body under anërobic conditions. Apparently *Bacillus botulinus* may remain in the intestinal tract of an animal for at least four months after contaminated food has been eaten.

Dissemination. *Bacillus botulinus* is widely distributed in nature. It is present in the garden and may be on the fruit and vegetables when they are picked. The organism is not necessarily associated with active decay. It may be present in the blemishes or spots on the skin of apparently sound fruit and vegetables. The evidence adduced by G. S. Burke in California tends to show that *Bacillus botulinus* may be closely associated with or disseminated by spiders or insects common in gardens in that state. Since *Bacillus botulinus* grows readily at temperatures as low as 22° C., there is no reason for assuming that this organism must be associated with the stools of warm-blooded animals.

Portal of Entry. The gastro-intestinal tract.

Incubation Period. Generally 20 to 24 hours, sometimes 36 hours.

Prophylaxis. Care and cleanliness in the handling and preservation of foodstuffs.

The ideal canning process would kill all spore-bearing organisms. This is exceedingly difficult to attain as the great resistance of certain strains of *Bacillus botulinus* to heat and other agencies emphasizes the danger that a few spores may occasionally survive almost any process of canning.

Sausage should not be eaten raw. The thorough cooking of canned goods before serving or sampling would destroy any *preformed* toxin.

Canned goods which show even minor changes of taste, odor or consistency should be rejected.

Dirty, wilted and partly rotted food should not be canned. Dirty tables, dirty jars and lids, sewage polluted water and flies should be eliminated from the canning industry.

A serviceable antitoxin is now prepared which has proved to be of both prophylactic and therapeutic value.

Food Poisoning

Synonym. "Ptomaine Poisoning."

Definition. Food poisoning, as distinguished from the intoxication due to the botulimus toxin, is an infection presenting either choleraic or gastro-intestinal symptoms induced by the presence of several related organisms of the colon-typhoid group.

Geographical Distribution. Outbreaks have been reported from all parts of the world.

Predisposing Conditions. The consumption of meat from sick animals and food that has been exposed to infection or to uncleanly conditions in storage, transportation, handling or preparation.

Infectious Agents. *Bacillus enteritidis, Bacillus suipestifer* and *Bacilli paratyphosus, A and B.*

Source of Infection. Infected food, especially meat. Outbreaks are due also to infected milk, milk products, vegetables, pastry and water.

Dissemination. The infection is spread by meat from sick animals and by food which has been contaminated by intestinal contents. Carriers are therefore responsible for a certain proportion of cases.

Portal of Entry. The gastro-intestinal tract.

Incubation Period. Usually within 48 hours.

Prophylaxis. Careful meat inspection and cleanliness in the handling and preparation of food. Medical examination of food handlers.

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